

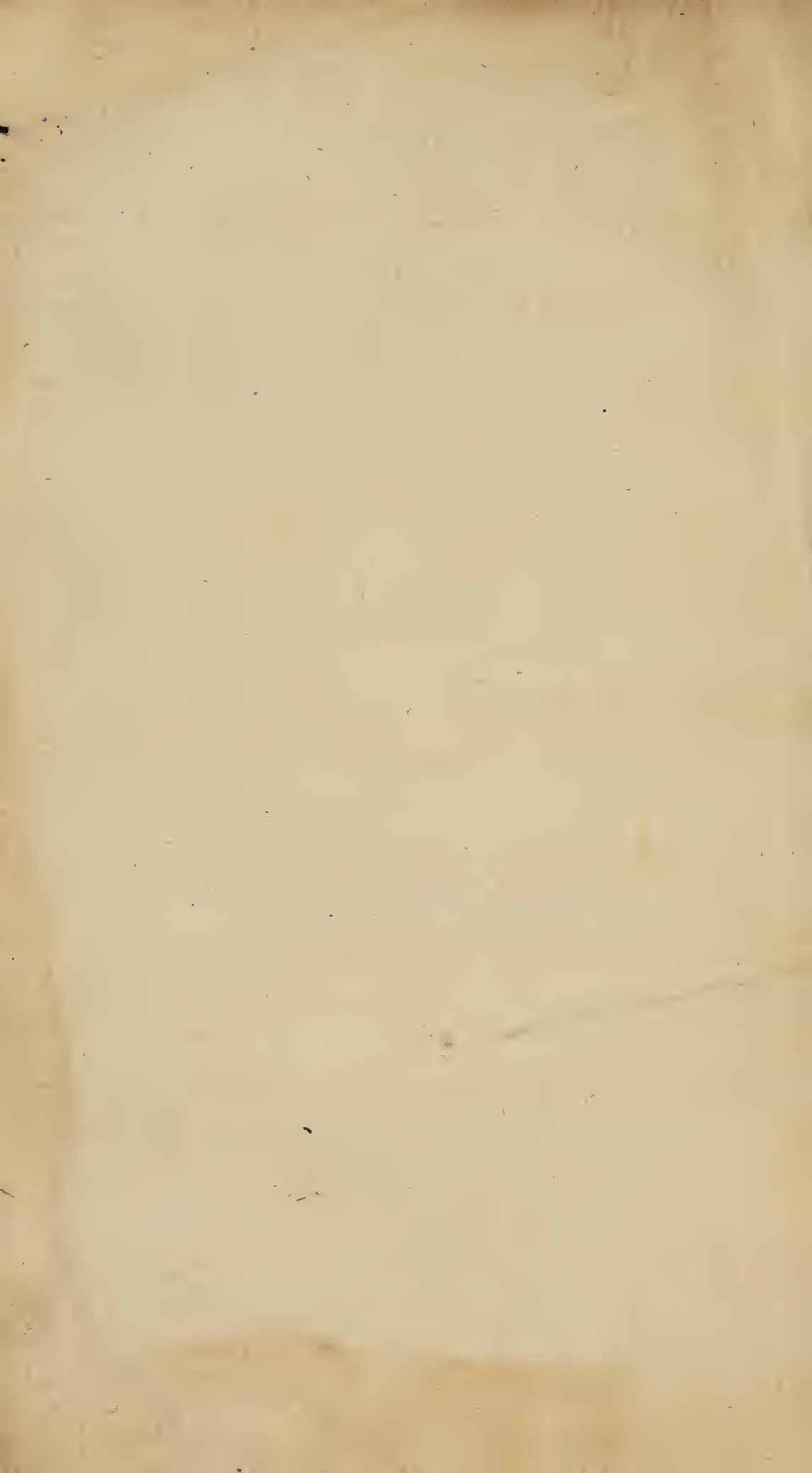
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ASTRO-THEOLOGY:

OR, A

J. M.
DEMONSTRATION

OF THE

BEING AND ATTRIBUTES

OF

G O D,

FROM A

Survey of the HEAVENS.

Illustrated with COPPER-PLATES.

By W. DERHAM, Canon of *Windsor*,
Rector of *Upminster*, in *Essex*, and F.R.S.

SEVENTH EDITION, much corrected.

GLASGOW:

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MD.CC.LV.



k

TO HIS ROYAL HIGHNESS

GEORGE,

Prince of WALES, Prince Electoral of *Brunswick, Lunenburg, &c.*

Duke of *Cornwell* and *Rothsay*, Duke and Marquess of *Cambridge*, Earl of *Chester, Milford Haven*, and *Carreck*, Viscount *North-Allerton*, Baron of *Tewksbury* and *Renfrew*, Lord of the Islands, and Steward of *Scotland*, and Knight of the most noble Order of the Garter.

GREAT SIR,

YOUR ROYAL HIGHNESS having done me so great an Honour as to take this Book under your Patronage with great Humility and Thankfulness I lay it at your Feet; not doubting but that (whatever my Performance is) the Subject will be acceptable, it being a Vindication of the EXISTENCE and ATTRIBUTES of that infinite BEING, to whom your Royal High-

DEDICATION.

ness hath no less piously than justly ascribed your great Royal FATHER'S and your Family's peaceable Accession to the Crown, and Dignity of these Realms.

THAT the Blessings of the same most merciful BEING may be perpetuated to your Royal Highness and all Yours, is the hearty Prayer of,

Most Illustrious S I R,

Your *Royal Highness's*

most humble obedient

Servant,

W. DERHAM.

TO THE R E A D E R.

NOtwithstanding that a book is more compleat and valuable by Additions and Amendments, yet I think that many and great Additions are an Hardship and Injustice to the Purchasers of a former Edition; and therefore I have in this, and the foregoing Editions, avoided it as much as well I could, although some of my learned Friends would have persuaded me to it; and also contributed their Observations.

But yet from what I have said in the *Preliminary Disc.* p. 3. it will, I doubt not, be expected, that I should give some account of the Observations, which the long and good Glasses in my hands have afforded me since the last Edition of this Book.

But I have little to boast of here, having (besides the old former complaint of the want of a long Pole to manage Mr. Huygens's Glass with) many great Hindrances in my Observations, partly by a very dangerous Fit of Sickness, which hung long about me; and partly by my necessary Affairs calling me to matters

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of another nature. But some of the most considerable of my Observations were these.

1. Viewing *Venus* with Mr. Huygens's Glass divers Nights, when near her Pedigee, and much horned, I thought I saw *Anfractus* or *Roughnesses* on the Concave Part of the enlighten'd Edge (such as we see in the New Moon) which I have represented as nearly as I could in *Fig. 12.*

2. In my frequent Views of *Jupiter*, I find his *Belts* to have great Varieties; that they change their Places; that their Breadths alter, being sometimes broader, sometimes considerably narrower; that sometimes they are more in Number, sometimes fewer; sometimes they are darker and blacker; sometimes thin and only like a Mist. Towards the Poles of *Jupiter* are the greatest Alterations, their being sometimes few or no *Belts* toward one or the other Pole; sometimes one quite across the polar Parts, another reaching but half, or a Part of the Way. And even about the middle, or equatorial Parts of *Jupiter*, where there are always *Belts*, (and commonly two) yet these vary considerably. Sometimes they are nearer one another; sometimes farther

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afunder : sometimes they are considerably broader, especially that nearest the middle ; sometimes as considerably narrower : sometimes they both advance towards one Pole ; and then recede towards the other opposite Pole. Of many of these Appearances I took Draughts, and designed to have enquired whether they had certain Periods ; but want of health and Leisure prevented me.

And not only the *Belts*, but the *Spots* also of *Jupiter* vary greatly ; I do not mean the *Spots* occasioned by the Shade of the *Satellites*, but such as are on the very Disk ; which are sometimes of one form, sometimes of another ; and oftentimes none to be seen at all, although the same Face of *Jupiter* should be towards us.

3. The last thing I shall mention is the *Nebulose*, which are those glaring whitish Appearances, seen with our Telescopes in *Andromeda's Girdle*, *Hercules's Back*, *Antinous's Foot*, *Orion's Sword*, in the *Centaur*, *Sagittary*, &c. which appear through the Telescope, somewhat after the manner, as *Cor Cancri* doth to the naked Eye.

These *Nebulose* I have often viewed with Glasses of very different lengths, particularly

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that in *pedi Antinoi* with Mr. *Huygens's* : but I confess that I could never discern what they are ; neither indeed could I perceive any great difference in their Appearances through a very good Glas of about 14 Foot, and others of 30 and 40 Foot, yea, Mr. *Huygens's* of 126.

But indeed the grand Obstacle to all my Views with Mr. *Huygens's* Glas was the Vapours near the Horizon, which not only obscured the Object, but caused so great a trembling and dancing thereof, as made it no less difficult to be distinctly and accurately viewed, than a Thing held in the Hand is, when danced and shaken backwards and forwards. By this means my Expectations from Mr. *Huygens's* Glas were frequently frustrated, excepting in Nights that were more than ordinarily serene and clear ; which was commonly in such as were the most intensely frosty and cold.

Finding it therefore unlikely that I should do much more with Mr. *Huygens's* Glas than I had done, I restored it to the *Royal Society* which lent it me, (and to whom Mr. *Huygens* bequeathed it by his last Will) contenting myself with the Views it had given me, and that I had discovered it to be an excellent Glas ; which Dr. *Hook*, and some others of

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our best *Judges*, took to be good for nothing.

And now having given this Account of my Observations, and also shewed what hindered my compleating of them (which may excite farther Enquiries, as well as serve to vindicate myself) I shall recommend these things to such as have good Glasses, particularly to the Diligence and Accuracy of my very ingenious Friend, the Reverend Mr. *Pound*, into whose hands the *Royal Society* have put that noble Request of Mr. Huygens, and who is so well accommodated for raising and using that Glass, as to have seen (among other considerable things) the five *Satellites* in *Saturn*; which I confess I could never reach, nor above three of them that I could be sure were *Satellites*: I say that I could be sure were such, because it is not very easy to distinguish which are *Satellites*, and which are small *Telescopic Stars*, which very frequently shew themselves in a Glass of such goodness as that is. I remember that I once verily thought I had found out seven *Satellites* of *Saturn*, with this very Glass of Mr. Huygens, so regularly were they placed in respect of *Saturn*. But when I came to examine them the following nights, I found

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that there were really no more than two *Satellites*, the rest being small Fixt Stars. But Mr. Pound's Skill and exactness in such Observations, is, I know, so great, (and I may add that of my sagacious friend Dr. Halley too, who I hear hath seen the same) that I do not say this by way of Caution to them, although it may serve as such to many others.

And now for a Close, I shall take this opportunity of publicly owning, with all honour and thankfulness, the generous Offer made me by some of my Friends, Eminent in their Stations, as well as Skill and Abilities in the laws, who would have made me a present of the *Maypole* in the *Strand*, which was to be taken down) or any other Pole I thought convenient for the management of Mr. Huygens's Glafs. But as my incapacity of accepting the favour of those noble *Mecænates*, hath been the occasion of that excellent Glafs being put into better hands; so I assure my self their expectations are abundantly answered, by the number and goodness of the Observations that have been and will be made therewith.

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A

PRELIMINARY DISCOURSE

CONCERNING

The systems of the heavens, the habitability of the planets, and a plurality of worlds, useful for the reading of the following book.

MY *Physico-Theology* having met with so quick a sale as to come to a third impression before the year was expired, but especially the solicitations of many learned men, both known and unknown, have given me great encouragement to fulfil my promise, in sending abroad this other part, relating to the *Heavens*: which should sooner have seen the light, but that I was minded not to interrupt the reader's patience with many notes (which I could not well avoid in my *Physico-Theology*, and which my rough draught of this was burdened with) and therefore I threw the greatest part of them into the text: which necessitated me to transcribe the whole. And when my hand was in, I new-made some part of it,

and added many new observations of my own, which I then had lately made with some very good long glasses I had in my hands; one of Campani's grinding; and others of English work, which exceeded it; but especially one of Mr. Huygens's of above 120 feet, which few for goodness do surpass.

Of these observations the reader should have met with many more (and I believe some of my ingenious friends do expect more) but that I lie under two inconveniencies: one the want of an open free Horizon, my habitation being surrounded much with trees. The other, and indeed the chief, the want of a long pole of a 100 or more feet, to raise my long glass to such an height, as to see the heavenly bodies above the thick vapours; which much obscure all objects near the Horizon, especially when viewed with such long and good glasses. But since that, two very dangerous fits of sickness, and the increase of my age, (both which have much impaired my sight) have render'd me incapable of such observations, especially at such seasons of the night and weather, as are fittest for viewing the heavenly bodies.

And therefore if I have not sufficiently answer'd the expectations of some of my learned and ingenious friends, I hope they will excuse

me, and believe it to be more my calamity than fault that I have done no more; especially among such planets as have advantageously presented themselves, as *Saturn* particularly hath, whose 5 or more *satellites* it may be expected I have seen; but I could never reach but three of them, and they only when there were but few vapours. And as for the spots in *Mars* and *Venus*, and their motion round their own axes, after I had a good furniture of excellent glasses, I had not any good views of those planets before my sickness, by reason of the too great distance of *Mars* from the earth, and the proximity of *Venus* to the Sun, and the cloudy weather; and the small altitude which *Venus* had above the Horizon about that time.

But however what is here wanting in my own, is sufficiently made up from the observations of others. Of which the learned world hath good store, since the invention of the telescope; which as it hath made ample discoveries of the works of God, so hath laid open a new, and a far more grand and noble scene of those works than the world before dreamt of, and afforded us a far more rational system of the heavens and the universe, than was before entertained.

And forasmuch as I have frequent occasions in my following book to speak of, and, according to some or other of the systems of the heavens, it is necessary I should, by way of preface, give some account of them, to enable such persons to understand my book as are unacquainted with astronomical matters.

Among all the various *systems*, I need take notice only of three, the *Ptolemaic*, the *Copernican*, and the *new system*. Of each of which in their order.

Of the Ptolemaic system.

In the *Ptolemaic system* the earth and waters are supposed to be in the center of the universe; next to which is the element of *air*, and next above that is the element of *fire*; next that the orb of *Mercury*, then that of *Venus*, then that of the *Sun*; and above the *Sun's* orb, those of *Mars*, *Jupiter*, and *Saturn*; and above them all, the *Firmament*, or orb of the *fixed stars*; then the *Crystalline Orbs*; and lastly, the *Coelum Empyreum*, or *Heaven of Heavens*. All these massy orbs, and vast bodies borne by them, are, in this system, supposed to move round the terraqueous globe once in twenty-four hours; and besides that,

in some other certain periodical times. For the effecting of which motions, they were forced to contrive such circles as they called *Eccentrics* and *Epicycles*, crossing and interfering with one another; which I could not represent in so narrow a compass as *Fig. 1.* is, which is a scheme of this *Ptolemaic system*; which is universally maintained by the *Peripatetic Philosophers*.

Of the Copernican system.

The next *system* is the *Pythagorean* or *Copernican*, being invented, as some imagine, by Pythagoras himself. But Diogenes Laertius (a) expressly saith, that Pythagoras's opinion was, "That the world was round, containing "the earth in the midst of it." And by Pliny's account (b) of Pythagoras his distances, and orders of the planets, this seems to have been his opinion. But the same Laertius (c) affirms Philolaus the *Pythagorean* τὴν γῆν κινεῖσθαι κατὰ κύκλον, πρῶτον εἰπεῖν οἱ δὲ, Ἰκετὰν ὑπὸ Σκουσιῶν φᾶσιν "to have been "the first that said the earth was moved in a "circle: but some say Hicetas the *Syracusan*."

a 3

(a) *Lib. 8. in Pythagora.*

(b) *Nat. Hist. L. 2. c. 21, 22.*

(c) *Ibid. in Philolaus.*

So Plutarch, in his life of *Numa*, speaking of *Numa's* building the temple of *Vesta*, saith,
 “ he built it round, and that a continual fire
 “ was kept therein, in imitation of the figure
 “ of the earth, or rather of the whole world
 “ itself, the middle of which the *Pythagoreans*
 “ (not *Pythagoras*) take to be the seat of
 “ fire.”

This system (whoever was the inventor of it) *Copernicus* a canon of *Thorn* restored about the beginning of the fifteenth century, and was followed therein by many considerable men, as *Rheticus*, *Maestlinus*, *Kepler*, *Rotham*, *Bullialdus*, *Lansberge*, *Herigonius*, *Shickard*, *Gassendus*, *Galilaeo*, and others. The last of which (by the ill-will and instigation of *Pope Urban VIII.* as it is supposed) had the misfortune to fall under the censure of, and to have his *Copernican Tenets* condemn'd by the inquisition, and was forced to abjure them. The particulars of which, if the reader hath a mind to see, he may find them in *Riccioli's Almagest* (d)

According to this system, the *Sun* is supposed to be in the center, and the heavens and earth to revolve round about him according to their several periods: First, *Mercury* in near

88 days; then *Venus* in somewhat above 224 days; then the earth with its satellite the *Moon*, in 365 one fourth days; then *Mars* in about 687 days; then *Jupiter* with his four moons in about 4333 days; and lastly, *Saturn* in somewhat above 10759 days, with his 5 or more moons revolving about him. And beyond or above all these, is the firmament, or the region of fixt Stars, which are all supposed to be at equal distances from their center the Sun.

This is the *Copernican system*, which I have given a scheme of in Fig. 2. And so far as this system relates to the motion of the earth, and the Sun resting in the center, I prefer it to the *Ptolemaic Hypothesis* on these five following accounts.

1. Because it is far more agreeable to nature, which never goes a round-about way, but always acts by the most compendious, easy and simple methods. And in the *Copernican* way, that is performed by one, or a few easy revolutions, which, in the other way, is made the work of the whole heavens, and of many strange and unnatural orbs. Thus the diurnal motion is accounted for by one revolution of the earth, which all the whole heavens are called for, in the other way; so for the periodical motions of the planets, their stations,

retrogradations and direct motions, they are all accounted for by one easy, single motion round the Sun, for which, in the *Ptolemaic* way, they are forced to invent divers strange, unnatural, interfering *Eccentrics* and *Epicycles*: An hypothesis so bungling and monstrous, as gave occasion to a certain king to say, “ If he
“ had been of God’s counsel when he made
“ the heavens, he could have taught him to
“ have mended his work.”

2. As the *Copernican* is far more easy and agreeable to nature than the *Ptolemaic* system, so it is far more complete, and answerable to the various Phaenomena of the planets; several of which the *Ptolemaic* hypothesis either very awkwardly solves, or doth not at all come up to. I might instance here in divers particulars relating to *Venus* and *Mercury*, as why the earth is never between them and the Sun, which the *Ptolemaic* system gives no tolerable account of, and but poor accounts of other of their Phaenomena, as also of those of the moon and the other planets. I might shew also how incoherent and improper the motions assigned to the heavenly bodies are in the *Ptolemaic* way, as that the moon should move round once in a month, the other planets in such and such periods as are assigned to them;

the firmament or fixt-stars in 25 or 26 thousand years; the sphere beyond that in 1700 years; and the tenth sphere in 3400 years; and the outermost of all, the *Primum Mobile*, which moves all the rest, in only 24 hours. Which are motions so unproportional, and disagreeable, that are sufficient to subvert the whole hypothesis. But it would be endless to enter into a detail of such incoherences and improprieties as the *Ptolemaic* system abounds with.

3. The prodigious and inconceivable rapidity assigned by the Ptolemaics to the heavens, is by the *Copernican* scheme taken off, and a far more easy, and tolerable motion substituted in its room. For is it not a far more easy motion for the earth to revolve round its own axis in 24 hours, than for so great a number of far more massy, and far distant globes, to revolve round the earth in the same space of time? If the maintainers of the *Ptolemaic* system do object against the motion of the earth, that it would make us dizzy, and shatter our globe to pieces, what a precipitant, how terrible a rapidity must that of the heavens be? What a velocity must the *Sun* have to run its course, at the distance of 21 or 22 Semidiameters of the earth? What a velocity must that of the fixt-stars, especially that of

the *Primum Mobile* be, at far greater distances than the Sun is?

4. It is an incontestible argument of the Sun being the centre of the Planets about him, and not the earth, that their motions and distances respect the *Sun*, and not the earth. For with regard to the *Sun*, the primary Planets have a very due motion, in proportion to their several distances; that is, their motions round the Sun, are in sesquiplicate proportion to their distances from him: but this proportion doth not hold at all with relation to the earth. But as for the secondary Planets, round *Saturn*, *Jupiter* and the earth, it is very certain that they have the same respect to their primaries, as these primaries have to the *Sun*; that is, “The squares
“ of their revolutions are as the cubes of their
“ distances.” And as it is very certain and visible, that the secondary Planets respect their primaries as their centers, and move round them, so it is in some measure (one would think) no less certain, and beyond doubt, that all the primary Planets which have the self-same respect to, and motion with regard to the Sun, as those secondaries have to their primaries, that those primaries, I say, do move round him as their center, and not about the earth, to whom they have no such respect.

5. The last argument I shall allege for my preference of the *Copernican* to the *Ptolemaic* system is from the great parity and congruity observable among all the works of the creation; which have a manifest harmony, and great agreement with one another.

Thus in our present case, it is manifest to our sight, that every globe we have any good views of, hath such like motions, as those are which we ascribe to the earth. The *Sun* indeed being in the center, is as it were fixt there, and hath no periodical motion: But yet the other motion round its own axis, we can manifestly discern. And as for all the Planets which move round about the *Sun*, they have, as far as 'tis possible for us to see them, such motions as those we ascribe to the earth; namely, a diurnal rotation round their own axes, and a periodical revolution round the *Sun*. And if this be manifest in the other Planets, what should hinder its being so in our own? Why should ours be singular? Why not be supposed to be moved as well as the rest, when it is very certain that either it hath those motions, or the heavens have so; and it is far more natural and easy for the earth to perform them, than for the heavens, as hath been already shewn?

Thus having shewn how far more probable the *Copernican* system is than the *Ptolemaic*, so far as it relates to the motions of the heavens and earth, and the *Sun* being in the center, it remains (before I proceed to the third and last system) that I should answer some objections alledged against this system, partly from scripture, and partly from philosophy and sight.

The objections from scripture are such as seem to assert the immobility and rest of the earth, and the motion of the *Sun* and heavenly bodies.

The texts that are brought to prove the immobility and rest of the earth, are, 1 Chron. xvi. 30. ‘The world shall be stable, that it be not moved.’ The same is said, Psalm xciii. 1. ‘The world also is established, that it cannot be moved.’ And so the same again, Psalm xcvi. 10. In Psalm civ. 5. GOD is said to ‘lay the foundations of the earth, that it should not be moved for ever.’ And lastly, Solomon, Eccles. i. 4. asserts, that ‘the earth abideth for ever.’ Like to which is that of the Psalmist, Psalm cxix. 90. ‘Thou hast established the earth, and it abideth.’ These are the principal texts which seem to assert the immobility and stability of the earth,

The principal texts which mention the motion of the *Sun* and heavenly bodies, are such as ascribe, rising, setting, or standing still to them. Thus Gen. xix. 23. ‘The *Sun* was
‘risen upon the earth, when *Lot* entered into
‘*Zoar*. And Gen. xv. 17. When the *Sun*
‘went down, and it was dark, a smoking furnace, &c. So Eccl. i. 5. The *Sun* ariseth,
‘and the *Sun* goeth down, and hasteth to
‘the place where he arose. So Psalm xix. 5,
‘6. the *Sun* is said to come out of his chamber like a bridegroom, and to rejoice as a
‘strong man to run a race. That his going
‘forth is from the end of heaven, and his circuit
‘unto the ends of it.’ Pursuant to which expressions of the *Sun*’s moving, it is said also
to stand still, and to go backwards. Thus Joshua x. 12, 13. ‘*Sun*, stand thou still upon
‘*Gideon*, and thou *Moon* in the valley of
‘*Ajalon*. And the *Sun* stood still, and the
‘*Moon* stayed.-----So the *Sun* stood still in the
‘midst of heaven, and hastened not to go down
‘about a whole day.’ And in 2 Kings xx. 10.
and Isaiah xxxviii. 8. the *Sun* is said ‘to have
‘returned ten degrees backward in one of the
‘places, and its shadow to have done so in the
‘other.’

These are the chief texts of scripture, which seem to lie against the Copernican hypothesis. In answer to which, this may be said in general to them all; that since the design of the holy writings is not to instruct men in philosophical, but divine matters, therefore it is not necessary to restrain the sense of those texts to the strict propriety of the words, but take them to be spoken according to the appearance of things, and the vulgar notions and opinions which men have of them, not according to their reality, or philosophical verity. Thus in divers other instances the holy scriptures speak; and thus even Philosophers themselves speak. Yea, the Copernicans themselves, although they professedly own, and defend the contrary; yet in vulgar speaking in our present case, say, The Sun riseth, setteth, and moveth, &c. making that to be the act of the *Sun* in vulgar discourse, which they contend, to be in reality performed by the earth. And if Philosophers, and others should not thus express themselves according to the appearance of things, and men's vulgar apprehensions of them, it would need a comment, and they must explain themselves every time they speak, in order to their being understood.

Having given this general answer, I shall next consider the particular texts themselves, and see whether they necessarily infer what they are brought for the proof of.

And in the first place, as for the texts brought to prove the immobility of the earth, it is manifest that the stability of the world, mentioned in the three first texts, doth not relate to the earth's motion, either annual or diurnal, but to the condition, state and order of the world inhabiting the earth, particularly the peace and prosperity thereof. One of our own latest, and most learned Commentators, the late bishop Patrick (e) understands the gospel-state to be meant in the first and third of the texts. And his paraphrase on that in Psalm xciii. 1. is, “ He who made the world, will
“ support that excellent order wherein we are
“ settled; so that it shall not be in the power
“ of men to disturb what he hath establish-
“ ed.”

As for what is said in Psalm civ. 5. it is manifest that the Psalmist is there celebrating the works of creation, and that there was as fair an occasion of speaking of the earth's

b 2

(c) See his Commentary on Chron. and Paraphrase on Psalms.

rest, in relation to its two motions, as any where. But yet even here also the security and permanency of its state is the thing aimed at. The last most learned Commentator thus paraphrases on the place, (f) “ Who hath settled the massy globe of the earth, even in the liquid air, upon such firm foundations, that none of those storms and tempests, which beat upon it from without, nor any commotions from within, can ever stir it out of the place he hath fixed for it.”

As for the two remaining places in Eccles. and Psalm cxix. it is plain enough that their design is to shew the vanity and instability of the things of this world, that they are all more fleeting and uncertain than other matters, even than the earth itself, on which they have their residence. In Eccles. the wise man (who had undertaken to prove all things here below to be vanity) begins with the state of man himself, and shews that to be more fickle and transitory than the earth, on which the various generations of men live, and to which their bodies do all return again. The generations of men pass away; *but the earth abideth for ever*, in the same unalterable condition,

(f) Bishop Patrick's Parap. on Psalm civ. 5.

without such going and coming as that of the generations of men have.

In Psalm cxix. 90. the Psalmist celebrates God's faithfulness to all the various and succeeding generations of the world, which he shews to be as constant and unalterable as the earth itself, which God hath so established, that it abideth through all the several generations of men, when they at the same time are fleeting and changing.

Thus it appears that all those several texts which assert the stability of the world, or earth, prove nothing against the earth's motion in a philosophical sense ; only express some moral theological truths.

And so the same may be said of those other places of scripture, which mention the motion of the *Sun* and other heavenly bodies, that say they rise, set, and perform the motions which the *Copernicans* ascribe to the earth. If we should take these expressions in a philosophical, strict, literal sense, and not as vulgar expressions, arising from the appearance of things ; we shall find that very odd and unreasonable conclusions may as well be collected from those scriptures, as the *Sun's* motion : as that the *Sun* hath animal life, motion, and desire, being said to act these things itself, to rise, to set,

yea, to haste to the place of his rising, or as the Hebrew hath it, to pant after, or eagerly to desire it (g). So in Psalm xix. the elegant Psalmist giving a poetical description of this noble and admirable work of God, the *Sun*, saith, ‘God hath, in the heavens, made a tabernacle for him;’ as if the *Sun* had an house, a resting-place provided for him; from which he comes daily forth with beauty and lustre, as resplendent as that of a bridegroom, and with the same ardency, joy and diligence runs his course, as a champion doth his race. And lastly, his going forth is said to be ‘from the end of the heaven, and his circuit to reach to the ends thereof;’ as tho’ the heavens had two extremities, or was (as the antients fancied the earth to be) a long large plane bounded by the ocean, under which they imagined the *Sun* betook himself, and was thence said *tingere se oceano*, to dip himself in the ocean when he set.

And as in these places of scripture the *Sun* is said to move; so in the other places he is said to stand still, and to go backward. But we shall find that very absurd conclusions would follow the taking of those texts in a strict

(g) SHAF *anhelavit*, *inhiavit*, vid. Buxtorf. Lexicon.

literal sense. For in *Joshuah* the *Sun* is ordered to stand still upon *Gideon*, and the *Moon* in the valley of *Ajalon*. But it would be very absurd to take this in a literal sense, and imagine those two great luminaries were confined to those two places, otherwise than in appearance to the victorious *Israelites*. And if so considerable a part of the transaction be spoken according to its appearance, why not the whole? Why might not this station as well be an arrest of the earth's motion as of that of the heavens, if the whole miracle was not (as some not improbably think) effected by means of some preternatural refractions, or extraordinary meteors? &c.

And so for the recess of the *Sun*, or its shadow in *Hezekiah's* case, that which in appearance seemed to be the action of the *Sun* is by divers learned men thought to have been the effect of such like extraordinary refractions or meteors, as I mentioned in the last case: or if it was a real recess, why not of the earth, rather than the *Sun* and whole heavens?

Thus having answered the particular texts; it doth not appear that the scriptures oppose the *Copernican* system, but that those passages which seem to do so, are spoken more according as things appear than as really they are.

For as St. Hierom saith, (h) “ *Consuetudinis*
 “ *scripturarum est*-----It is the custom of the
 “ scriptures, for the historian so to relate the
 “ opinion men had of many matters, as at
 “ that time those matters were by all people
 “ taken to be.” And in another place, (i)
 “ There are many things in the Holy Scrip-
 “ tures, which are spoken according to the
 “ opinion of the time in which they were
 “ done, and not according to their reality.”
 And this is no other than what is very reason-
 able, and suitable to the end and design of the
 Holy Scriptures, which as I have said, is ra-
 ther to instruct men in divine and moral doc-
 trines than philosophical truths. And agree-
 ably hereto St. Augustine answers this very
 doubt concerning the motion of the heavens.
 (k) “ Some of the brethren (saith he) move
 “ a question, whether the heavens stand still
 “ or are moved, because, say they, if they
 “ are moved, how is it a firmament? and if
 “ they stand still, how do the stars, which are
 “ believed to be fixed in them, revolve from
 “ east to west, the northern stars describing
 “ lesser circles near the pole?-----To which,

(h) Hieron in Matth. c. 13.

(i) In Jerem. xxviii.

(k) August. de Genesi ad Literam. L. 2. c. 10.

“ faith he, I answer, That these things do
“ greatly require several subtil and laborious
“ reasons, to discover truly whether the mat-
“ ter be so, or not so. For the entering upon,
“ and discussing of which, I have neither
“ time, neither is it fit it should be done to
“ such as we desire to instruct in the way of
“ salvation, for the necessary benefit of the
“ holy church.”

Having thus answered the objections from scripture, I shall in the last place consider those brought from sense and philosophy.

The objection from sense is, that we see the heavenly bodies actually to move, and therefore ought to believe they do so. But there is no weight at all in this, because whether we ourselves, or the object moveth, it amounts to the same. As is manifest to any one carried in a boat or chariot; the progressive motion of which, produceth the appearance of a regressive motion in the unmoved objects we look upon; according to Virgil's description of Aeneas and his company's leaving their port.

(1) *Provehimur portu, terraeque urbesque
recedunt.*

(1) Aeneid. L. iii. v. 72.

i. e. “Both land and towns receded when we
“left our port.” As for the reason hereof,
I shall refer to the opinions, particularly the
famous Kepler, who in his *Optices Astronom.*
hath designedly handled this point.

The objections from philosophy, are too
numerous to be distinctly answered, especially
such as seem very frivolous, particularly those
grounded on a supposition of the verity of the
Aristotelian philosophy, as the immutability
and incorruptibility of the heavens, &c. For
answers to which, I shall refer the reader to
Galilaeo's *System Mund.* But for such objec-
tions as seem to have some reason in them,
they are chiefly these, That if the earth be
moved from W. to E. a bullet shot west-ward
would have a farther range, than one shot
east-ward; or if shot N. or S. it would miss
the mark; or if perpendicularly upright, it
would drop to the west-ward of the gun. That
a weight dropp'd from the top of a tower would
not fall down just at the bottom of the tower,
as we see it doth. That birds flying towards
the E. would be hindred in their flight, but
forwarded in flying the contrary way; with
much more to the same purpose. But not to
enter into a detail of answers that might be
given to the preceeding objections from the

laws of motion, and the rules of mechanics and mathematics; I shall only make use of the most ingenious Galilaeo's plain experiment, which answereth all or most of the Objections (m). ' Shut, *saieth he*, yourself up with your
' friend in the great cabin of a ship, together
' with a parcel of gnats and flies, and other
' little winged creatures, Procure also a great
' tub of water, and put fishes therein. Hang
' also a bottle of water up, to empty itself
' drop by drop into another such bottle placed
' underneath with a narrow neck. Whilst the
' ship lies still, diligently observe how those
' little winged creatures fly with the like swift-
' nefs towards every part of the cabin; how
' the fishes swim indifferently towards all sides;
' and how the descending drops all fall into the
' bottle underneath. And if you throw any
' thing to your friend, you need use no more
' force one way than another, provided the
' distance be equal. And if you leap, you
' will reach as far one way as the other.
' Having observed these particulars whilst the
' ship lies still, make the ship to sail with what
' velocity you please, and so long as the mo-
' tion is uniform, not fluctuating this way and

‘ that way, you shall not perceive there is
‘ any alteration in the aforesaid effects ; neither
‘ can you from them conclude whether the
‘ ship moveth or standeth still. But in leap-
‘ ing you shall reach as far on the floor as you
‘ did before ; nor by reason of the ship’s mo-
‘ tion, shall you make a longer leap towards
‘ the poop than the prow, notwithstanding that
‘ whilst you were up in the air, the floor under
‘ your feet had run the contrary way to
‘ your leap. And if you cast any thing to your
‘ companion, you need use no more strength
‘ to make it reach him, if he should be to-
‘ wards the prow, and you towards the poop,
‘ than if you stood in a contrary position. The
‘ drops shall all fall into the lower bottle, and
‘ not one towards the poop, altho’ the ship
‘ shall have run many feet, whilst the drop
‘ was in the air. The fishes in the water shall
‘ have no more trouble in swimming towards
‘ the fore-part of the tub, than towards the
‘ hinder part, but shall make towards the bait
‘ with equal swiftness, on any side of the tub.
‘ And lastly the gnat and flies shall continue
‘ their flight indifferently towards all parts,
‘ never be driven together towards the side
‘ of the cabin next the prow, as if wearied
‘ with following the swift motion of the ship.

‘ And if by burning a few grains of incense,
‘ you make a little smoak you shall perceive
‘ it to ascend on high, and hang like a cloud,
‘ moving indifferently this way and that, with-
‘ out any inclination to one side more than a-
‘ nother. The cause of which correspondence
‘ of the effects, is, that the ship’s motion is
‘ common to all things contained in it, and to
‘ the air also: I mean when those things are
‘ shut up in the cabin: but when they are a-
‘ bove deck in the open air, and not obliged
‘ to follow the ship’s course, differences more
‘ or less may arise among the fore-named ef-
‘ fects.’

Thus Galilaeo by this one observation hath answered the most considerable objections deduced from philosophy against the motion of the earth. And thus much shall suffice for the explication and proof of the *Copernican system*; especially that part of it relating to the *Solar system*. Which things I have more largely than ordinary insisted on, for the satisfaction of many that I am sensible doubt of them, and particularly some of my friends (and those not unlearned too) who may be apt to read my following book with prejudice wheresoever I favour the *Copernican* notions.

Of the New System.

And now I pass from the second system to the third, which is called the *new system*, and by some the *true system*; which extends the universe to a far more immense compass, than any of the other systems do, even to an indefinite space; and replenishes it with a far more grand retinue than ever was before ascribed unto it.

The *new system* is the same with the *Copernican*, as to the system of the *Sun* and its planets; as may be seen by the scheme of it in *Fig. 3*. But then, whereas the *Copernican* hypothesis supposeth the firmament of the fixt-stars to be the bounds of the universe, and to be placed at equal distance from its center the *Sun*; the *new system* supposeth there are many other systems of *Suns* and *Planets*, besides that in which we have our residence: namely, that every fixt star is a *Sun*, and encompassed with a system of planets, both primary and secondary as well as ours.

These several systems of the fixt stars, as they are at a great and sufficient distance from the *Sun* and us, so they are imagined to be at as due and regular distances from one another.

By which means it is, that those multitudes of fixt stars appear to us of different magnitudes, the nearest to us large ; those farther and farther, less and less.

Of those systems of the fixt stars I have given a rude representation in *Fig. 3.* together with that of the *Sun* ; which may serve to give an unskilful reader some conception of the state of the universe ; although there be but little likeness in it, for want of room to lay out all the several systems in due proportion ; which is necessary to a true representation of the matter.

In this 3d. *Fig.* the fixt stars with their systems (represented by little circles about those stars, which circles signify the orbits of their respective planets) are placed without the limits of the solar system, and the solar system is set in the center of the universe, and figured as a more grand and magnificent part thereof. And so it may be looked upon by us, by reason of its proximity and relation to us. But whether it be really so, whether it be in the center of the universe, and whether among all the noble train of fixt stars, there be no system exceeding ours in its magnificent retinue of planets, both primary and

secondary, and other admirable contrivances, is a difficulty, as out of the reach of our glasses, so consequently above our ability to fathom, although not at all improbable. But be the various systems of the universe as they will as to their dignity, it is sufficient that in all probability there are many of them, even as many as there are fixt stars, which are without number.

This system of the universe, as it is physically demonstrable, so is what, for the most part, I have followed in the ensuing book, but not so rigorously and obstinately, as utterly to exclude or oppugn any other system; because as the works of GOD are truly great, and sufficiently manifest their excellent and magnificence in any system; so I was willing to shew the same in such systems as I had occasion to speak of them in; because I would not offend, and consequently not bar the force of my arguments upon such readers, as might happen to be wedded to the *Aristotelian* principles, or prejudiced to the *Ptolemaic*, or any other *system*: Not that I had myself any doubts about this *new system*, but think it to be far the most rational and probable of any, for these reasons.

1. Because it is far the most magnificent of any; and worthy of an infinite CREATOR; whose power and wisdom as they are without bounds or measure, so may in all probability exert themselves in the creation of many systems as well as one. And as myriads of systems are more for the glory of GOD, and more demonstrate his attributes than one; so it is no less probable than possible, there may be many besides this which we have the privilege of living in. But it is very highly probable the matter is so, by reason,

2. We see it is really so, as far as it is possible it can be discerned by us, at such immense distances as those systems of the fixt stars are from us. Our glasses are indeed too weak so to reach those systems, as to give us any assurance of our seeing the planets themselves, that encompass any of the fixt stars. We cannot say we see them actually moving round their respective Suns or Stars. But this we can discern, *viz.* That the fixt stars have the nature of Suns, as I have made probable in Book 2. Chap. 2. As also that there are some things very like unto planets, which sometimes appear and disappear in the regions of the fixt

stars; as I have shewn in my discourse of *new stars*, Book 2. Chap. 3.

But besides what I have said there, I have this farther to add from some late observations I have made since my writing that part of my book; and that is, That the *Galaxy* being well known to be the fertile place of the *new stars*, the region in which they commonly appear, I am much inclined to be of opinion, that the whiteness there, is not caused by the bare light of the great number of fixt stars in that place, as hath commonly been thought, but partly by their light, and partly (if not chiefly) by the reflections of their planets; which stop and reflect, intermix and blend the light of their respective Stars or Suns, and so cause the whiteness of the *Galaxy* presents us with; which hath rather the colour of the reflected light of our *Moon* than the primary light of our *Sun*.

. And that there are planets enough for this purpose, I suspect, because I have some reasons to imagine that there are many more *new stars* in the *milky-way* (all which I take to be a kind of planetary globes) than have ever yet been taken notice of, and that many of those prodigious numbers of telescopical stars visible there, are of the numbers of *new stars* or pla-

nets, and not of *fixt stars* only. This suspicion I have for some time had, but especially lately from my views of the *new star* that now begins to disappear in the *Swan's neck*. Which gave me occasion to inspect some other parts of that constellation, most parts of which are well replenished with a numerous train of small stars. Amongst which, sometimes methoughts more have presented themselves thro' one and the same glass, and sometimes I have mist some I thought I before saw: And sometimes also methoughts I have seen them nearer to, and sometimes farther off those stars that did constantly present themselves. But as these things are to myself novel, and what I confess I have rather suspicions of than certainty, I shall refer them to the future observations of myself, and others, for their confirmation; especially because those approximations and recesses of some of the little stars I speak of suit not with the observations of some very eminent Astronomers.

These observations as they will open to us a new and admirable scene of the heavens (if it be as I imagine) so I earnestly recommended the enquiry into it to such as delight in those matters. For the doing of which, I conceive it may be sufficient, and the easiest course to

make the observations in some one part of the milky-way, as in some part of the *Swan* for instance; and I would advise that an area of the heavens may be taken in, containing as much or a little more than falleth within the compass of the telescope you make use of: Which was the way I practised, and that part of the heavens, in which I observed. All the stars that fall within this area, an exact map must be taken of, which will shew when any variations happen. And for taking in the larger area of the heavens, a glass of 6 or 8 feet is sufficient, and rather better for the purpose than longer glasses, which take in less, and are more troublesome in using.

Having thus represented the state of the universe according to the *new system* of it, the usual question is, what is the use of so many planets as we see about the *Sun*, and so many as are imagined to be about the fixt stars? To which the answer is, That they are worlds, or places of habitation, which is concluded from their being habitable, and well provided for habitation. This is pretty manifest in our solar planets, from their being opake bodies as our earth is, consisting in all probability of land and waters, hills and valleys, having atmospheres about them, moons ministring unto

them, and being enlightned, warmed and influenced by the *Sun*; whose yearly visits they receive, for seasons; and frequent returns or revolutions, for days and nights. All which particulars are fully treated of in the following book, and need not therefore to be anticipated here. Only there is one thing, which for sufficient observations, I could not so fully speak of as I would; and that concerning the *seas in the moon*, in book 5. chap. 4. Note (a) whose very existence Mr. Huygens (n) denies, saying, *Marium vero similitudinem illic nullam reperio. &c. i. e.* “In the moon
 “ I find no likeness of seas, although Kepler
 “ and most others are of a different opinion.
 “ For those vast plane regions, which are
 “ much darker than the mountainous parts,
 “ and are commonly taken for seas, and bear
 “ the names of oceans; in those very places
 “ viewed with a long telescope, I find little
 “ round cavities with shadows falling within
 “ them; which cannot agree with the surface
 “ of the sea: as also those very large fields
 “ when carefully viewed, do not present us
 “ with a superficies altogether equal. Where-
 “ fore these cannot be seas, but are such pla-

(n) *Cosmotheoros*, p. 114.

“ ces as consist of a less bright matter than that
“ which is in the more hilly parts, but in
“ which also there are some places brighter
“ than others.” Thus the most ingenious
Mr. Huygens, who then proceeds to shew that
there are neither rivers, clouds, air, or vapours.

But that there are seas or great collections of water, and consequently rivers, clouds, air and vapours in the moon, I shall make out from some of my own views and observations; many of which were made with Mr. Huygen's own long glass before-mentioned: through which, and all other long glasses, instead of imagining the lunar spots to be unlike seas, I have always thought them to look more like seas, than through short glasses.

It is true indeed that in those spots we take to be seas, there are such cavities as Mr. Huygens speaks of, or rather mountains with shaded cavities in them, as also some parts less dark than others. Thus in the southerly parts of the *Lunar Euxine* and *Mediterranean*, in the *Sinus Sirbonis*, the *Egyptian*, and divers other seas, there are several such parts that appear more luminous than others, some having the appearance of rocks and islands, some of large shallows, particularly towards the

shores, and especially in the seas bordering on the continents, such as the great southern continent of the *Lunar Egypt* and *Palestine*. But this is no conclusive argument of those parts not being seas; because they may be seas having many islands and shallows in them. But then in other parts, and even in some parts of these last named, the spots appear darker, and with but few of those eminences or islands, those brighter or shallow parts. Thus the northerly *Euxine* and *Mediterranean*, the *Palus Maeotis*, and many other of those lunar seas; few of those parts that have the aspect of islands or shallows are to be discerned in them, only one here, and another there, at considerable distances from one another.

And in this very manner I doubt not our terraqueous globe would appear, if viewed at the moon, or at some miles aloft. We should there perceive our deep oceans would be of a darker colour, like the darkest spots of the moon; and the single isles of *St. Helena* and *Ascension*, and the more numerous ones of *Ladrones*, *Canaries*, *Azores*, &c. to have the same appearance that the few scatter'd islands have in the deeper lunar seas: and our shallow seas with their numerous rocks and

islands dispersed about them, especially towards the continents, would look as those in the moon do.

That a reader unacquainted with the geography of the moon, may apprehend what I have said here and elsewhere, concerning the parts and appearances of the moon, I have represented them in *Fig. 10.* and *11.* In *Fig. 10.* the face of the full moon is represented, its bright and dark parts with most of the names given them by Hevelius, whose lunar geography is justly the most followed. In *Fig. 11.* I have represented the appearance of the moon's edge on this last *Nov. 4. 1714.* soon after the quadrature, for the explication of what is said concerning the evenness of the surface of the lunar spots in book 5. chap. 4. note *a.* It may be there observed that the surfaces of all the seas appear strait and level, only the top of here and there a rock or island presents itself at a small distance. Thus the surface of the *Hyperborean* sea between *a* and *b* appears even and level, although through a telescope that sea looks but like a great lake or marsh. So do the parts of the *Mediterranean* about *d*, from *b* to *i*, except when they are interrupted by rocks or land, as they are at *b*, *g*, *b*, and *c*. At the last of which places,

begins a ridge of hills encompassing the northern part of the *Mediterranean*, which makes a pretty shew in the telescope.

And now considering how accomplished the *Moon*, and all the other planets are for habitation, how solemn an apparatus in them for this service: and considering also that these accoutrements relate to their respective planets only, and in all probability are of little or no use to our earth; with great reason therefore the maintainers of the new system conclude those planets, yea all the planets of the Sun and of the fixt stars also, to be *habitable worlds*; places, as accommodated for habitations, so stocked with proper inhabitants.

But now the next question commonly put is, What creatures are they inhabited with? But this is a difficulty not to be resolved without a revelation, or far better instruments than the world hath hitherto been acquainted with. But if the reader should have a mind to amuse himself with probable guesses about the furniture of the planets of our solar system, what countries 'tis probable are there, what vegetables are produced, what minerals and metals are afforded, what animals live there, what parts, faculties and endowments they have,

with much more to the same purpose; he may find a pleasant entertainment enough in the great Mr. Christian Huygen's *Cosmotheoros* and some other authors that have written on the subject. To which I shall refer him, rather than give either him or myself any farther trouble about these matters, which are merely conjectural.

Thus having, for the sake of the unskilful reader, given an account of the three *systems* principally concerned in the following book, and having also, for the sake of the doubting reader, insisted more largely than ordinary upon the two last of those systems, little remaineth for the putting an end to this long preface, but to make my excuse (if it needs any) for assigning the diameters and distances of the heavenly bodies in English miles, rather than other larger measures, which would perhaps have come nearer the truth. But this was also for the sake of such as are not very conversant in astronomical matters and dimensions, who can better understand you, when you say, it is so many miles, than so many degrees, minutes, or seconds, or semi-diameters of the earth, or the other planets.

And now for a conclusion, I shall only intreat all my readers to join with me in their

earnest prayers, - that as this work is designed for the good of mankind, particularly for the conviction of infidels and irreligious, for the promotion of the fear and honour of GOD, and the cultivating of true religion, so it may have its desired effect.

W. DERHAM.



A
S U R V E Y
OF THE
H E A V E N S.

The I N T R O D U C T I O N.

THE Psalmist saith, (a) “ The heavens declare the glory of GOD; and the firmament sheweth, ” publicly declareth, telleth forth, or preacheth his *handy-work*, as the Hebrew word signifies; (b) that “ day unto day uttereth speech, and night unto night sheweth, ” or telleth forth, *Knowledge*. Which language of the heavens is so plain, and their characters so legible, that all, even the most barbarous nations, that have no skill either in languages or letters are able to understand and read what they proclaim. “ There is no speech nor language where their
d 3

(a) *Psal.* xix. 1, 2, 3.

(b) *Nagad* significat aliquid verbis efferre, coram nuntiare, annunciare, *Cornad. Kircher, Concord. Col.* 226. *Vol. 2. It is derived from Neged, coram, ante.*

voice is not heard: their line is gone out through all the earth, and their words to the end of the world."

That this observation of the *Psalmist* is agreeable to experience, is manifest from the deductions which all nations have made from God's works, particularly from those of the heavens; namely, that there is a GOD; and that such as have pretended to atheism, and have deduced God's works from Chance, &c. are singular and monstrous in their opinions. Thus saith Aelian (c) "There never was any
 " barbarian that contemned the Deity, nor
 " called in question whether there be any Gods
 " or no? or whether they take care of human
 " affairs? No man, neither *Indian*, nor *Celt*,
 " nor *Aegyptian* ever entertained any such
 " thought as *Eumerus* the *Messenian*, or *Dio-*
 " *nysius* the *Phrygian*, or *Hippo*, or *Diago-*
 " *ras*, or *Socias*, or *Epicurus*." So one of *Pla-*
to's arguments for the proof of a God, is (d)
 " the unanimous consent of all, both Greeks
 " and Barbarians, who confess there are Gods."
 And *Plutarch* (e), agreeable to what our *Psal-*
mist affirms, tells us whence they collected this

(c) *De variis hist. lib. 2. cap. 31.*

(d) *De Legibus L. 10.*

(e) *De placit. philos. L. 1. c. 6.*

knowledge of a Deity. “Men, *saith he*, began
“to acknowledge a God, when they saw the
“stars maintain so great a harmony, and the
“days and nights *through all the year*, both
“in summer and winter to observe their stat-
“ed risings and settings.” And to pass over
a great deal of this kind, that I could cite from
diverse heathen authors, “What, *saith the Stoick*
“in Tully, (f) can be so plain and clear, as
“when we behold the heavens, and view the
“heavenly bodies, that *we should conclude*
“there is some Deity of a most excellent mind,
“by which these things are governed! —A
“present and Almighty God. Which he
“that doubts of, I do not understand, *saith*
“*he*, why he should not as well doubt whe-
“ther there be a Sun or no *that shines*.” And
then he goes on to prove that this can be no
idle fancy depending on the caprice of man,
but a well-grounded substantial opinion, bearing
the test of ages, and confirmed by the length
of time. “For, *saith he*, time wears out the
“figments of opinions, but confirms the judg-
“ments of nature ;” or such notions as are
grounded upon the true judgment and nature

(f) Quid enim potest esse tam apertum, tamque perspicuum, cum coelum suspeximus, &c. *De Nat. Deor.*
L. 2. c. 2.

4 *The Heavens declare, &c.*

of things. “ For which reason, *saieth he*, both
“ among our selves, and in other nations, the
“ veneration of the Gods, and the sacredness
“ of religion augment and improve every day
“ more and more.”

Thus ‘ the heavens declare the glory of
God,’ even to the heathen world, so manifest-
ly are they the handy-work of God. And that
they are his work, will appear by taking a
view of these seven particulars.

I. The magnitude of the heavens.

II. The great number of the heavenly bodies.

III. Their distances.

IV. Their motions.

V. Their figures.

VI. Their gravity.

VII. Their light and heat, and the admi-
rable provisions made for those benefits.

BOOK

BOOK I.

Of the MAGNITUDE of the UNIVERSE,
and the bodies therein contained.

CHAP. I.

The Antient and Modern Reckonings compared.

BEFORE the invention of the telescope, the universe was thought to be confin'd within far more narrow bounds than it is since found to be, the fixt stars being imagined to be all placed in the starry heavens (which they called the *Firmament*) at equal distances from the earth (the center) like so many golden nails driven in the top of some arched roof, or other circular concave, encompassing our eye. These, although far more narrow bounds, and a more scanty reckoning than it should be, yet was sufficient to shew who was the maker of such a stupendous arch, and so noble a train as is contained therein.

But according to the modern reckoning (which is far the most rational, and grounded upon better Phaenomena) we shall find this branch of the creation far more magnificent,

and worthy of its infinite CREATOR than those former computations made it.

And how grand and magnificent a structure the heavens are, will appear by a distinct consideration of the magnitude of the heavenly bodies themselves; and of the space in which they are.

C H A P. II.

The MAGNITUDE of the Heavenly Bodies.

ALthough we are not able to give a certain determination of the magnitude of the heavenly bodies, by reason of their vast distances, yet enough we know, and are sure of concerning their immense magnitudes, to convince any one that they are the works of God. But to come to particulars.

The measure by which we usually gauge and compare the heavenly bodies, is our teraqueous globe; of whose dimensions and bulk we can make a pretty good estimate, having tolerably good and accurate observations leading us thereto: the particulars of which I have had occasion elsewhere to specify (a).

(a) *Phyfico-Theol. B. 2. Ch. 2. In which place I have made use of Mr. Picart's measure of the earth. But notwithstanding the difference be but small, viz. a little*

The Magnitude of the other Planets. 7

By these observations it appears that the diameter of this our globe is above 79 hundred miles; that consequently its surface is a good deal above 199 millions of miles, and its solid content or bulk near 265 thousand millions of miles. If therefore we should go no farther from home than our own globe, a mass we here have worthy of an infinite Creator, a work proclaiming that great Being that made it.

But as vast a body as this seems to be, it is much less than many, yea most of the heavenly bodies that are visible to us, except two or three of the planets, which seem to be less than our globe, namely *Mars*, whose diameter is reckoned to be but 4875 English miles, and the *Moon*, whose diameter is but 2175 miles; and *Mercury*, whose diameter is 2748 miles (b);

above 32 miles in the whole diameter of our globe, yet I shall make use here of our Mr. Norwood's and Mons. Cassini's measures, because they agree to almost a nicety, and Mr. Cassini's were made (by the French king's command) at greater distances, with the greatest accuracy. And according to these measures, the diameter of the earth is 7967.7 English miles, its surface 199444201 miles, and its solid content 264856000000 miles.

(b) *The number of miles which I have here, and all along assigned to the diameters of the several planets, are the mean numbers between Mr. Flamsteed's in Mr. Whiston's astronomical lectures, and Mr. Huygen's in his Syst. Saturn. and Cosmotheor. which (as Mr. Whiston first suggested to me) seem to be nearest the truth. For whereas the rays of light when intercepted by the edge of*

8 *The Magnitude of the other Planets.* Book I.

but yet these are vast and amazing bodies too. But for the rest; there is a good reason to imagine their bulk exceeds that of our terraqueous globe. Thus the two superior planets by far exceed us; *Saturn* being computed at 93451 miles in diameter, and consequently at 427318300000000 miles in its bulk; and *Jupiter* at 120653 miles in diameter, and 920011200000000 miles in bulk. But yet as amazing masses as these all are, yet they are all far outdone by that stupendous globe of fire, the *Sun*; which as it is the fountain of light and heat to all the planets about it, affording them, by his benign rays and kindly influence, the great pleasures and comforts of life; so doth it as far surpass them in its bulk; its apparent diameter being computed at 822148 English miles, and its solid content at

a knife or other body, are (as Sir Isaac Newton observes in his Princip. L. 1. Prop. 96.) somewhat bent, as if attracted from a strait line by that body: and whereas Mr. Flamsteed's measures were taken with a micrometre that pinches or clasps the opposite edges of a planet which would incurvate the rays one way; and Mr. Huygen's were taken with the interposition of a thin tapering plate covering the planet as far as the extremity of its face, which would cause an incurvation of the rays the contrary way; therefore Mr. Flamsteed's measures are as much too little, as Mr. Huygen's are too large, and consequently the mean between them probably the nearest the truth.

290971000000000000 miles supposing the face we see of the Sun to be its true and real globe.

Thus stupendous are the magnitudes of the globes of this our *Solar System*. But these are not all, nor perhaps the most considerable bodies, of the universe. For the fixt stars, although in appearance but so many golden or flaming spots, yet are with great probability, supposed to be so many Suns, surrounded with their respective systems of planets, as our Sun is; and imagined to be no less in magnitude, if not greater, (some of them at least) than our Sun is, but only diminished in appearance by their prodigious distances from us.

If now we reflect upon the prodigious masses of those many heavenly bodies that present themselves to our view; and many more I shall shew are unseen; what a surprising scene do the heavens afford us of the great CREATOR'S power! A train of such immense bodies, that what less than an Almighty hand could first find matter sufficient for, and then compose, such magnificent works! But yet what is the magnitude of all these bodies to that immense space in which they are? Which is the next thing to be considered.

A

C H A P. III.

Of the IMMENSITY of the heavens.

IT is necessary that I should give a distinct consideration to the immense space possessed by the heavenly bodies, because it was once imagined to be limited by the narrower bounds of the *Ptolemaic System* by that which they called the *απλανης*, the *Starry Concameration*, or *Firmament* of the fixt stars, as I have before intimated; but now with far greater probability, and reason, it is extended to an indefinitely larger space, a space sufficient, without all doubt, to contain all the noble variety of systems therein; not only our own of the *Sun*, but all those others I mentioned of the fixt stars also. But for the better proof, and more easy apprehension of the magnitude of this vast expanded space, let it be considered.

I. That some, if not every one, of those vast globes of the universe hath a motion. This is, in some, manifest to our sight; and may easily be concluded of all, from the constant similitude and consent that the works of nature have with one another. But in what manner

these motions are performed, whether by the motion of the heavenly bodies round the earth, or by the earth round its own axis, or any other way, it matters not much now to enquire.

2. It is manifest that the earth is set at such a due distance from the heavenly bodies, and the heavenly bodies at such a due distance from one another, as not to interfere, clash with, or disorder one another. Nay so great is their distance, so convenient their situation, that they do not so much as eclipse one another, except such planets as are called Secondary.

3. It is farther manifest also, That those vast bodies are so far off, as to appear extremely small to our eye, considering their prodigious magnitudes. Now for the effecting of this, or any of the other matters, it is necessary that there be a sufficient space; and, that there is such, and what that space is, we may make a judgment of, by considering particulars, according to the best observations we have of these things.

And to begin nearest home; the nearest of the heavenly bodies to us, is the *Moon*; whose orb is the least of any of the celestial globes, but yet she takes up a space of near 480

thousand English miles in breadth (a) to perform her revolution in. And as for the earth, if, with the moderns, we suppose it, together with its satellite the *Moon*, to revolve round the *Sun*; or (which amounts to the same thing) if the *Sun* revolves round the earth, this *Magnus Orbis*, as it is usually called, is a space of above 540 millions of miles circumference (b);

(a) *The Moon's mean distance from the earth according to Sir Isaac Newton's Princip. p. 430. is 60 Semidiameters one fourth of the earth, according to which the diameter of the Moon's orbit is 479905 English miles.*

(b) *Concerning the distance between the Sun and the earth, there is a great disagreement between the former and latter Astronomers, occasioned by the disagreement between their observations of the Sun's horizontal parallax (which is equal to the earth's semidiameter viewed at the Sun) Tycho making it three minutes, Kepler but one, Bullialdus 2 minutes, 21 seconds, and Riccioli but 28 seconds. Consequently the distances arising from hence are less than those of the latter Astronomers. The very ingenious and accurate Mons. de La Hire in his Tabul. Astron. thinks the Sun's horizontal parallax to be not above 6 seconds, and his distance therefore to be 34377 semidiameters of the earth, or 136952807 English miles. But although his observations were made since, yet I shall make use of Mons. Cassini's number, being deduced from very ingenious and accurate observations of the parallax of Mars, and agreeing nearly with the determination of two great men, Mr. Flamsteed and Mr. Huygens, and I may add Dr. Halley too, who make it about 10 or 12000 diameters of the earth. That great Astronomer (Mons. Cassini I mean) assigns a number between them, in his Les Elemens de l'Astron. § 37. That the Sun's parallax being supposed to be 9 one half Seconds, gives the distance of the Sun from the earth 21600 semidiameters of the*

or 172 millions of miles breadth. And if to that we add the increment caused by the sweep of the *Moon*, or the excursion of her orb beyond the *Magnus Orbis*, we shall have a space yet broader by near 280 thousand miles. But as vast a space as this seems to be, yet it is not such as to cause either the earth or *Moon* to clash with any of the other celestial globes, as I have said; nay so far from that, that not so much as their shade approaches any of them. In which case, what ample orbs must the three superior planets have? what a space is necessary for them and their more numerous *Moons* to perform their much larger courses in? And accordingly, such spaces they and the rest of the planets are all found to have: *Saturn* an orb of 1641526386 English miles diameter; *Jupiter* an orb of 895134000 miles; *Mars* of 262282910 miles; *Venus* of 124487114 miles; and *Mercury* an orb of 66621000

A 3

earth: which are equal to 86051398 English miles. And imagining the *magnus orbis* to be a circle (as it is indeed an ellipsis not much differing from a circle) the double of that number is the length of its diameter, viz. 172102795 English miles.

These numbers are different from those I have assigned in my *Pylico-Theol. B. I. ch. 4. Note 5.* from a mistake at that time.

English miles (c): all of them spaces so accurately laid out, and distances so duly proportioned to their revolutions about the *Sun*, that abundantly manifest infinite wisdom to have been concerned in their appointment, as I intend to shew in proper place.

But now after this account of this so prodigious a space as that of our *Solar System* is, what is it to the nearly infinite *Expansum* occupied by the rest of the heavenly bodies! Of which we may have a faint adumbration by considering the distances which, with the greatest probability of observation and reason, are assigned to the *Fixt Stars*. In order to the making an estimate of which matter, let it be supposed (which is usually allowed) that the fixt stars are so many *Suns*; that they are of the same, or nearly the same magnitude as our *Sun* is; and that the difference of their magnitudes ariseth from the difference of their distances. If so, then it will follow, That the fixt stars are each of them as much farther from us than the *Sun*, as their apparent diameters,

(c) *These numbers are deduced from the distance between the Sun and earth assigned in the preceeding note, and Sir Isaac Newton's distances of the planets from the Sun computed from their periods in his Principia L.3. Phaenom. 4. and are, as I humbly conceive, much more accurate than other calculations that I have met with.*

are less than that of the *Sun* (d). And forasmuch as few of them appear otherwise than as points even through our best telescopes, therefore how prodigiously farther must they needs be from us than the *Sun* is, to cause their appearance to be so very much less than the *Sun*? For an example, let us take one of the fixt stars supposed to be nearest to us, as being the brightest and largest, namely *Syrius*. Now this, by accurate observations (e) hath been found to be in appearance 27664 times less than the *Sun*; and consequently, by the foregoing rule, it is so many times farther off than the *Sun* is, which will amount to above 2 millions of millions of English miles. And if so, what an immensurable space is the firmament? wherein a great number of stars lesser and lesser, and consequently (according to the foregoing supposition) farther and farther off, are seen with our naked eye, and many more discovered with our glasses, and still many more and more with better glasses (f), and in

(d) Compare the sagacious Dr. David Gregory's demonstration of this in his *Astron. L. 3. Prop. 56, 60, and 61.*

(e) See Mr. Huygens in *Cosmotheor. p. 137.*

(f) In viewing the planets with my longer glasses [especially the planets of a weaker light] it often falls out that divers of the fixt Stars, and some of them very small,

all probability many others that escape the reach of our utmost art to descry: which may consequently be as far distant from those we see as those are from us.

present themselves at the same time within the glass, notwithstanding its area is not sufficient to contain both Jupiter and his most distant satellites. By which means it is sometimes difficult to distinguish between those fix'd Stars and the satellites of the planets. Thus I have sometimes been ready to fancy that I saw one or more satellites near Mars, untill by future observations I perceived they were only some of the telescopic fix'd Stars lying in the way of Mars. So about Saturn, I have often discerned the likeness of many satellites, but I am not sure I ever saw above three. From whence it is manifest, that in all parts of the heavens there are many Stars which present themselves to our eye through our long glasses, that are otherwise invisible to us.

C H A P. IV.

Practical Deductions from, and Reflections upon the MAGNITUDE of the Heavens.

HAVING set forth the prodigious magnitude of the heavenly space, and of the bodies therein contained, before we proceed farther, let us pause a little, to consider what influence these things ought to have upon us.

And in short, who can behold the regions above, and consider the things therein contained,

and at the same time not own them to *declare the glory of God*? Who can view that immensurable firmament in which those bodies are, and not acknowledge his handy-work? We admire, (as justly we may) the vast bulk of this our own globe: but when we consider how much it is surpassed by most of the heavenly bodies, what a point it degenerates into, and how very little more even It, and what we call its *great Orb* together also, are, when seen from the heavens, this gives us a just and noble idea of the infinite Creator's works, such as is worthy of God, and such as may make us slight, not overvalue this little heap on which we dwell, and cause our thoughts and desires to soar among the heavenly glories. But for an application of these considerations, let us hear Seneca's reflections upon the matter (g), who on this account recommends virtue, not purely
“ because it is a noble thing in its own nature;
“ and a great blessing to be free from evil;
“ but also because it enlargeth the mind, and
“ prepares it for the knowledge of heavenly
“ things, and makes it fit to associate with
“ God (h).----Then, *saieth he*, the mind hath
“ the consummate and full good of our hu-

(g) *Nat. Quaest. L. i. Praefat.*(h) *Qui in consortium Dei veniat.*

“ man state, when having conquered all evil,
“ it soars aloft, and wandering among the stars
“ above, it is able to deride the stately struc-
“ tures of the wealthy, and all their riches.----
“ Neither, *saith he*, can it condemn the porches
“ and roofs shining with ivory, the clip’t
“ groves, and the pleasant streams conveyed
“ to their houses, until it hath wandered
“ throughout the world, and from above look-
“ ing down upon this little globe, covered in
“ a great measure by the sea, and, where
“ not so, slovenly, and either burnt up in
“ one part, or frozen in the other, it then
“ saith to itself, Is this that little point that is
“ divided among so many nations by fire and
“ sword? Oh how ridiculous are the bounds of
“ mortals,” when this river divides this na-
tion, that mountain boundeth another, and that
desart another? For as for this world, saith he,
“ It is a point in which ye sail, in which ye
“ war, in which ye dispose of kingdoms. But
“ above, are vast spaces, into the possession
“ whereof the mind is admitted, on condition
“ it hath brought but little of the body along
“ with it, that it hath cleansed itself from eve-
“ ry filthy thing, and being disengaged from
“ the world hath made itself illustrious, by
“ being expeditious and light, and content

“ with little things. When such a mind,
“ *saith he*, hath touched those celestial re-
“ gions, it is then nourished and grows; and
“ as if delivered from its bonds, it returns
“ to its original state. And this argument it
“ hath of its divinity, that it delights in divine
“ matters, and is conversant with them, not as
“ things strange, but its own. There it secure-
“ ly beholds the rising and setting stars, their
“ different courses, &c. There this curious
“ spectator discusses every thing, and searches
“ out every thing. And indeed what should
“ it do but pry into these matters, since he
“ knows they belong to himself? Then he
“ contemns the narrow bounds of his habita-
“ tion in this world——And here at last he
“ learns what he hath long enquired after;
“ There he begins to know God (i).”

(i) Illic incipit DEUM nosse.

BOOK II.

The great NUMBER of the Heavenly bodies.

C H A P. I.

A general View of the NUMBERS of the Heavenly Bodies.

HA V I N G in the preceeding book given a demonstration of God from the *magnitude* of the heavenly bodies, I shall do the same in this from their *number*; a number so great, that we cannot view and consider them without astonishment. Were there no more of them than the Sun, and the planets (both primary and secondary) supposed to move about him, there would be a number sufficient to manifest an Almighty and wise CREATOR. But when we view the heavens, and see ourselves surrounded with so prodigious a number of illustrious bodies, of various magnitudes; when we go to the other parts of this our globe, from the northern, suppose to the southern pole, andt here discover a great multitude of other stars that were never seen in our hemisphere: when we perceive the heavens thick be set with

them in every place; and when (as I already hinted) we view the heavens with our glasses, and discover many more than our naked eye could reach; and when we again view them with better and better instruments, and still discover more and more of those starry globes; when particularly we survey what they call the *Milky-way*, and see the prodigious number, I may almost say clusters of stars, that fill that region of the heavens, and cause that remarkable whiteness there: I say, when we see such prodigious numbers of those heavenly bodies, which no art of man can number; and when we farther consider, that in all probability we do not see the half, nay perchance not the thousandth part of what the heavens do contain; as we cannot but be struck with amazement at such a multitude of God's glorious works, so we cannot but own the *great CREATOR* in them; and we are worse than men, if we do not give him his due praises.

B

C H A P. II.

That the fixt Stars are Suns encompassed with Systems of Planets.

ALTHOUGH the number of the erratic and fixt heavenly bodies we see are sufficient to set forth the existence and praises of their *great* CREATOR, yet there is one thing more that I cannot easily pass over (though it hath only high probabilities for it) because it gives us a far more noble and agreeable idea of the creation, than the world was ever, that we know of, acquainted with before; and that is, That the best and most learned modern Astronomers do generally suppose the great multitude of fixt stars we see, or imagine to be in the universe, to be so many *Suns*, and each of them encompassed with a system of *Planets* like our Sun.

And that the *Fixt Stars* are *Suns*, or of much the same nature as our Sun, there is great reason to conclude,

1. Because they are bodies no less immense (as I have said) than the Sun, but only diminished in appearance, by their prodigious distances from us.

2. Because they shine by their own native light, not by any borrowed from the Sun. For so great are their distances from the Sun, and from us also, that it is not possible their light should be received from the Sun, and reflected to us, as that of the Moon and other planets is. And withal, so brisk and vivid is their light, and so very small their apparent diameters, when divested of their glaring rays, and made to have their true appearance through our telescopes, that no question is to be made, but that they shine by their own innate light, as our Sun doth.

And if the fixt Stars are so many Suns, certainly they minister to some grand uses in the universe, far above what hath usually been attributed unto them. And what more probable uses, than to perform the office of so many Suns? that is, to enlighten and warm as many systems of planets; after the manner as our Sun doth the erratics encompassing it. And that this is the use and office of the fixt stars is probable,

1. Because this is a far more probable and suitable use for so many Suns, so many glorious bodies, than to say they were made only to enlighten and influence our lesser, and I

may say inferior, globe; which another Moon or two, or one or two of those very Suns set nearer to us, would have better done, than all the whole train of heavenly bodies now doth. But instead of this, many of them, nay perhaps the greatest number of them are at such immense distances (as shall be shewn under the next head) that they are out of the reach of our naked eye. In which case, what use is it likely such great numbers of such immense, unseen, far distant bodies can be to our world, when there are so many already of divers magnitudes of those that fall under view, that (besides other much greater uses they may serve unto in the universe) do minister to our help and comfort here upon earth, in supplying the absence of the Sun and Moon by night?

2. From the parity, and constant uniformity observable in all God's works, we have great reason to conclude that every fixt star hath a system of planets, as well as the Sun. For it is certain that the Sun is a fixt star to the fixt stars, as they are to the Sun. And in this case, if (as the justly renowned Mr. Christian (j)

(j) *Cosmotheoros*, p. 133.

Huygens argues) “ we should imagine our-
 “ selves to be placed somewhere in the heaven-
 “ ly regions, as far from the Sun as from the
 “ fixt stars, we should then perceive no dif-
 “ ference between the one or the other. For
 “ it would be very unlikely that we should
 “ see any of the solar planets, either by rea-
 “ son of the diminishing of their light, or be-
 “ cause their orbs would sink into the same
 “ lucid point with that of the Sun. Being
 “ then so placed, we should imagine all these
 “ stars (*both Sun and fixt stars*) to be much
 “ of the same nature and kind; and from a
 “ view of any one of them nearer to us than
 “ the rest, we should make our judgment of
 “ them all. And now being, *saith he*, by the
 “ favour of God, admitted so near one of
 “ them, namely the Sun, as to see six lesser
 “ globes revolving round about him, and other
 “ Secondary ones revolving round some of
 “ them: why ought we not to have the same
 “ judgment of the rest of those Suns, as of
 “ this, and think it altogether probable that
 “ this is not the only star of all the number
 “ that is encompassed with such a train, or in
 “ any respect excells the rest? Neither also

“ that this star alone revolves round its own
“ axis, but rather that all the rest have some.
“ what of the same kind also.” And so that
learned person goes on in the further pursuit
of his ingenious argument.

3. Besides those strong probabilities, we have this farther to recommend those imaginations to us, that this account of the universe is far more magnificent, worthy of, and becoming the infinite CREATOR, than any other of the narrower schemes. For here we have the works of the creation, not confined to the more scanty limits of the orb, or arch of the fixt stars, or even the larger space of the *Primum Mobile*, which the antients fancied were the utmost bounds of the universe, but they are extended to a far larger, as well as more probable, even an indefinite, space; as was set forth in the first Book. Also in this prospect of the creation, as the earth is discarded from being the center of the universe, so neither do we make the uses and offices of all the glorious bodies of the universe to center therein; nay in man alone, according to the old vulgar opinion, that *all things were made for man* (k)

(k) See *Physico-Theol.* B. 2. c. 6. N. 3.

But in this our scheme we have a far more extensive, grand, and noble view of God's works: a far greater number of them; not those alone that former ages saw, but multitudes of others that the telescope hath discovered since; and all these far more orderly placed throughout the heavens, and at more due and agreeable distances, and made to serve to much more noble and proper ends: for here we have not one system of Sun and planets alone, and one only habitable globe, but myriads of systems, and more of habitable worlds (1), and some even in our own solar system, as well as those of the fixt stars. And consequently if in the Sun and its planets, altho' viewed only here upon the earth at a great distance, we find enough to entertain our eye, to captivate our understanding, to excite our admiration and praises of the infinite CREATOR and Contriver of them; what an augmentation of these glories shall we find in great multitudes of them! in all those systems of the fixt stars throughout the universe, that I have spoken of, and shall have occasion to mention again in the next chapter!

(1) See the preface, p. 20.

C H A P. III.

Of New Stars.

BESIDES the planets of our solar system, and the wonderful number of fixt stars, there are some others, which are called *New Stars*, which sometimes appear and disappear in divers parts of the heavens, and will deserve a place here.

Some of these new stars have been taken notice of as early as Hipparchus's time, who
 ‘ seeing such a new star, and doubting whether
 ‘ it often happened, and whether the stars we
 ‘ take to be fixt were so or no; he *therefore*,
 ‘ (as (m) Pliny tells us) set upon numbering
 ‘ the stars for posterity; a difficult task, *he*
 ‘ saith, even for a god: and by proper instru-
 ‘ ments he marshalled them in such order,
 ‘ that their places and magnitudes might be
 ‘ known: by which means it might be easily
 ‘ found, not only whether they decayed and
 ‘ perished; or were again renewed; but also
 ‘ whether any of them changed their places, or
 ‘ had any motion, as also whether they increas-
 ‘ ed or decreased.” Thus Pliny.

(m) *Plin. Nat. Hist. L. 2. c. 26.*

Since which time many other such new stars have been taken notice of by others. To pass by the new stars in Hadrian's, Valentinian's, Honorius's, and Otto's times, I shall name only such as have been more lately taken notice of by men of good judgment in these matters; such were those new stars observ'd by Tycho Brahe, David Fabricius, Janson, Bayer, Kepler, Marius, Byrgius, Holwarda, Hevelius, Montanari, Bullialdus, Cassini, our Mr. Flamsteed, and some others (n) to which may be added a *New Star* that appears at this very time I am writing, in the neck of the Swan; the same in all probability that hath been seen before by Mr. Kirch, (o) in 1687, and 1688,

(n) For a catalogue of these and other new Stars, the constellations in which they appeared, and other matters relating to them, I shall refer to Riccioli's *Almagest*. Lib. 8. §. 2. cap. 1. Hevelii *Prodrom*. in his description of the comet in 1665. p. 433. the appendix to Mercator's *Astron*. and Mr. Lowthurp's *Abrig*. vol. 1. p. 247.

(o) In the *Miscellanea Berolinensia*, p. 210. Mr. Kirch, saith he, for some time, sought this Star in vain, but at last on August 6. N. S. 1687. he found it with the help of an 8 foot tube, but very small, and that it grew bigger and bigger, so as on October 23. to be seen with the naked eye, until having arrived to its greatest magnitude, it again became less and less, and at last invisible even in a telescope. By frequent observations he discovered its motion to be very regular, and its period to be 404 and a half days.

and perhaps by Bayer before, as also Hevelius and others.

Of these *New Stars*, there is reason to imagine there may be many, by reason they are not confined to one part of the heavens, but appear and disappear in divers constellations, and divers parts of those constellations, as in Cassiopeia, the Swan, the Great Bear, Andromeda, Eridanus, the Whale, the Ship, and divers other parts of the heavens.

What these *New Stars* are, is hard to determine. *Meteors* they cannot be, because they are of a long continuance, and much too far off, for bodies that emit so little light as *Meteors* do, to be seen by us. And as for other opinions about them, they are too many, and too frivolous (some of them) to be named (p) except one or two of the most probable. Among which, one is of some that think they may be such Stars as have one side darker than the other, as one of *Saturn's satellites* is supposed to have, and so appear only when the bright side is turned towards us, and disappear as the darker takes place. Some think they

(p) If the reader hath a mind to see a variety of these opinions, he may find them largely enough handled in *Riccioli's Almagest. ubi supra c. 17.*

may be fixt Stars that expire in light and vapours and (q) are again rekindled, and recruited by the access of comets. Others take them to be comets themselves. But if I may be admitted to speak what was formerly my own opinion, I rather took them to be *Erratics* of some kind or other; and that for those reasons:

1. From some of them, as I thought, seeming to change their places, and appearing sometimes farther off, and sometimes nearer unto other Stars: as I have said in the preface.

2. From that increase and decrease of their light and magnitudes which is constantly observed in them; they being at first obscure, and hardly discernable, but by degrees growing bigger and brighter, till some of them equal the light of *Venus*; and others the light of the fixt Stars, of the first, second, and third magnitudes: and then again as gradually grow less and less till they utterly disappear.

3. From their Periodical motion and return after a certain time. This indeed hath not

(q) This is what Sir Isaac Newton surmises in his princip. L. 3. prop. 42.

been so carefully and judiciously taken notice of as it deserves, or so as to bring their periods under certain determinations ; but yet in some of Hevelius's and Cassini's observations, it hath been discovered that some of the same stars have returned, as particularly that in the Whale's Neck, and that which now appears in the Swan's Neck, which as I just before (pag. 29) said, hath a period of 404 onehalf days, according to Mr. Kirch's observations.

These were my reasons for suspecting those *New Stars* to be *Erratics*, rather than *Fixt Stars* either recruited, or having dark and light sides.

But the grand difficulty is, what kind of *Erratics* they are, whether *Wandering Suns*, or *Planets* (like ours) of other systems? That they should be *Wandering Suns*, is somewhat odd to assert: and of what use they should be, is hard to imagine, since there is nothing of this kind in the universe, that we know of, that may assist our imagination.

And as to the latter opinion, I confess I have been much inclined to suspect that they might be Planets revolving round such Suns, as cast a much fiercer and more vigorous light than our Sun doth ; and that these their planets

might be more dense than ours, and have surfaces more strongly reflecting light, and perhaps be much larger too. But notwithstanding that *Planetary reflected light* may be sent to very great distances by these means, yet without extravagant suppositions of this nature, it may be doubted whether it would reach us, so far off as the fixt stars are. And besides this, another doubt is, That although there are divers stars near those new stars, of greater magnitudes than any of those new stars are, which I ever yet have had the fortune to see; yet I can scarce think them big enough, to conclude them to be the Suns about which those new Stars (if planets) move. And therefore being uncertain what to determine in so intricate a matter, I shall leave it to future better observations (which the late long dark weather hath hindred me in the prosecution of) which I hope may afford us so good light, as may lead us into a much greater knowledge of those rare Phaenomena.

But whatever those new stars are, they are a farther demonstration of GOD's power and glory: and that there are many more of the grand works of the creation than what our eyes behold at all, or that we have only now and

then a glimpse of. But if they are planets of other systems, some of those Erratics revolving round some of the fixt stars, then do they lay open a still more glorious scene of GOD's works, and give us such a representation of the state of the Universe, that the world never dreamt of before, and that even angels themselves may be amazed at the sight of.



Book III.

The due SITUATION of the Heavenly Bodies.

C H A P. I.

Of the due as well as great DISTANCE of the Heavenly Bodies.

I HAVE before taken notice of the immense distance of the heavenly bodies, that it is such as makes those vast bodies the fixt Stars (no less in all probability, as I said, than the Sun itself) to degenerate into so many points, yea to escape our eye; nay more than this, that it causeth even our own *Great Orb* which our earth describes about the Sun, to sink into almost a point, or at least a circle of but a few seconds diameter. I shall therefore say no more on that matter. But that which I shall speak of in this book, is the due proportion of the distances of the heavenly bodies, that they are not set at random, like a work of chance, but placed regularly, and in due order, according to the best methods of proportion and contrivance. Which will be manifest from the following chapters, which will shew that the distance is such, that none of the globes interfere

with one another: but instead of that, are in due and the most nice, commodious proportion.

C H A P. II.

That none of the Globes of the Universe interfere.

HAD the Universe been the work of chance, or any thing but of a wise Architect, there would have been a great many blunders and inconveniences in the situation of such a prodigious number of immense globes, as the Universe doth contain. Some would have been too near, some too far off, some would have met with, knock'd and stop'd one the other, and some would have so interfer'd as to have incommoded the other, some way or other. But instead of this, every globe throughout the whole creation is, as far as it is possible for us to observe, set at such a due distance, as not only to avoid all violent concourses, but also so as not to eclipse or shade one the other, wherever it may be prejudicial, or indeed not useful and convenient, or so as to hinder one anothers kindly influences, or to prejudice one

another by noxious ones. This is very manifest in our own system of the Sun; and because we see it not otherwise, we may conclude it to be so in all; unless we should make some exception for what is suspected (and indeed only suspected) of Comets, which in their approaches towards the earth, are imagined to cause diseases, famines and other such like judgments of God. But this is only surmise, and what befalls the world at other times, without the visible approach of any comet. But however, supposing that as Comets move in Orbs very different from those of the other heavenly bodies, so their effects and influences may be as different; yet this may be, and no doubt is (because it may be proved) with the concurrence, and by the appointment of the divine Providence; who, as Governor of the world, might make such noxious globes to execute his justice, by affrighting and chastising sinful men, at their approaches to the earth; and not only so, but (as some have imagined) to be the place of their habitation and torment after death. But supposing it to be so, yet herein is a kind providence manifested, That their returns to

the earth are but seldom (a), and their stays short, and that they take up many years in passing the rest of their Orbs.

And now whether we consider the due situation of the greatest part of the heavenly bodies, whereby neither they, nor their influences do interfere; or the more unusual position and motion of Comets, still it appears that a wise and careful architect was the contriver and orderer of itall: especially if we join what follows in the next chapter.

(a) There having of late been great expectations among some, of a Comet appearing this year 1718, it may gratify their curiosity to take notice, in this place, of the three Comets, whose periods we imagine, are discovered, by the great sagacity and application of our modern Astronomers. The revolution of the first of the three, is supposed to be performed in 75 years; and to have been the same Comet that appeared in the year 1682. The second is supposed to be the Comet that was seen in the year 1661, and to revolve round in 129 years. And the third is imagined to be that Comet which appeared in 1680 and 1681, whose period is 575 years. And according to Mr. Whiston's determinations, the first of these three Comets will again appear in the year 1758, the second in 1789, and the third and last not till about the year 2255.

C H A P. III.

Of the nice Proportions of the Distances of the Heavenly Bodies.

AS it is one great demonstration of the ingenuity and skill of an architect to give due proportions to his work; so we find this to be abundantly manifest in all the bodies of the universe that fall under our cognizance: among which we may discern a curious order, and that due and nice proportions are strictly observed in their situation.

How the fixt Stars are situated in respect to one another, is impossible for us to determine at such prodigious distances as they are from us; but they look to us, who can have no regular prospect of their positions, as if placed without any order: like as we should judge of an army of orderly, well disciplined soldiers, at a distance, which would appear to us in a confused manner, until we came near and had a regular prospect of them, which we should then find to stand well in rank and file. So doubtless, if we could have an advantageous prospect of the fixt Stars, we should find them

very commodiously, and well set in the firmament in regard of one another. And this we have great reason to conclude from the rules of parity, from that constant harmony, and similitude observable among all the works of the creation, which fall under our cognizance: particularly this is evident in this region of the Universe, to which we belong, and which we have a better prospect of, and can survey with our instruments, I mean the system of the Sun. In this we find every body placed in good order, and at due distance, according even to the nicest rules of proportion.

For the eviſion of this matter, let us (according to the moſt received and rational Hypotheſis) ſuppoſe the Sun placed in the center, to influence all his planets with light and heat. Then follow the ſeveral planets, ſurrounding him, not one here, and another there, at all adventures, in a rude manner, like a work of *Chance*, but at due diſtances from the Sun; at proper diſtances from one another; and in ſuch well adjusted proportion of their velocities and gravities, as makes the ſquares of their revolutions in proportion to the cubes of their diſtances. And this is what is diſcernible

in the whole solar system; not only in the primary planets that revolve round the Sun, but in the secondary planets also, that revolve round Them. Thus it manifestly is in the five *Moons* that accompany *Saturn*, and the four accompanying *Jupiter*. And a most sagacious contrivance this is, manifesting the presence and conduct of the CREATOR, in thus chusing this proportion I spake of, rather than any other. For should the power of gravity (for instance) have been so constituted, as to decrease in the proportion of the cubes (instead of the squares) of the distances reciprocally; although it might be possible to adjust a velocity, and I may add, a direction too, so as to make bodies describe perfect circles, yet the least excess or defect of velocity or the least obliquity of the direction, would make them describe spiral curves, either ascending *in infinitum*, or else descending to the center. And supposing the orbs (in which those bodies move, and which are supposed, as I said, to be made in proportion of the cubes) to be perfectly circular, the least adventitious force, even but of an atom, abating or increasing the velocity, or changing the direction, would bring on the aforesaid inconveniencies. And if the great

CREATOR and contriver of the Universe hath thus wisely modelled, and cautiously methodized this part, this system of it where we live, and behold the thing, no great doubt can be made but that he hath done the same in the other systems thereof also; that every system is set at a due distance from one the other, and every body in each system at its due distance also from their Sun, or fixt star.

And now who can reflect upon these things, and not perceive and admire the hand that acteth in them, the contrivance and power of an infinite workman! For where we have such manifest strokes of wise order, counsel, and management, of the observance of mathematical proportions, can we conclude there was any thing less than reason, judgment, and mathematical skill in the case? or that this could be effected by any other power, but that of an intelligent Being who had wisdom and power sufficient for such a work: according to the reasoning of the Stoick in Cicero, who pleads thus (r) “ If
“ thou shouldst see a large and fair house, thou
“ couldst not be brought to imagine that house was
“ built by the mice and weasles, although thou

(r) *Cic. de Nat. Deor. L. 2. c. 6.*

“ shouldst not see the master thereof; so (*saieth*
“ *he*) wouldst thou not think thyself very plain-
“ ly to play the fool, if thou shouldst imagine
“ so orderly a frame of the world, so great a
“ variety and beauty of heavenly things, so
“ prodigious a quantity and magnitude of
“ sea and land to be thy house, thy workman-
“ ship, and not that of the immortal Gods!”

And so when we see such good order, such due proportions in this region of the Universe, and have good reason to conclude the same may be throughout the whole, can we, without great violence to reason, imagine this to be any other than the work of God?

B O O K IV.

Of the MOTIONS of the H E A V E N S.

C H A P. I.

That the bare Motion of the Heavens and Earth are a Demonstration of God.

IN treating concerning the motion of the heavenly bodies, it will be necessary to take in that of the earth too, it being not easy to speak of one without the other. And here there are two things that are manifest demonstrations of the presence and management of **GOD**, namely, that such bodies should move at all, and that their motion is so regular.

1. That all those vast globes of the universe should have a motion, must of necessity be from some being that had power enough to put them in motion. For as Lactantius well argues (a) “ There is indeed a power in the “ Stars,” (and the like may be said of the rest of the globes) of “ performing their mo-

(a) *Lactant. Divin. Instit. L. 2. c. 5.*

tions, but that is the power of God, who made and governs all things, not of the Stars themselves that are moved. " For it is impossible for such lifeless, dull, unwieldy bodies to move themselves, but what motion they have, they must receive from something else able to move them.

Now this some will say may be effected by the *Vortices* surrounding the Sun, the earth, or other primary mover (b); or from a vectorial power or emanations of the Sun, (c) or other the like primary movers carrying about and pushing on such bodies as move about them. But allowing that it is possible it might be so, yet still we must recur to some *First Mover*, some *Primary Agent*, who was able to set that principal mover into motion : and then the case amounts to much the same, and the argument hath the same force, whether we attribute the motion of one, or all the several globes to the power of GOD. For in our solar system, for instance, if it should be thought that the six primary planets revolving round the Sun, received their motion from his revolution

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(b) *This was Cartes' notion, and of others long before him.*

(c) *This was Kepler's Scheme.*

round his own axis; yet let us think (*as Plato*
 “ *argues*) (d) how it is possible for so prodigi-
 “ ous a mass to be carried round for so long a
 “ time, by any natural cause? For which rea-
 “ son (*saieth he*) I assert God to be the cause,
 “ and that it is impossible it should be other-
 “ wise.” Thus Plato: whose argument is
 undoubtedly good, since, as Aristotle argues (e),
 “ Every thing that is moved, must of necessity
 “ be moved by some other thing; and that
 “ thing must be moved by something that is
 “ moved either by another, or not by another
 “ thing. If it be moved by that which is mov-
 “ ed by another, we must of necessity (*saieth*
 “ *he*) come to some prime Mover, that is not
 “ moved by another. For it is impossible that
 “ what moveth, and is moved by another,
 “ shall proceed *in infinitum*.”

And now therefore, if in our solar system,
 we should imagine the Moon to be wheeled
 about our earth, by the motion and vectorial
 power of the earth; and the moons about *Sa-*
turn and *Jupiter* by the motion and vectorial
 power of those planets; and all the primary

(d) PLATO *in Epinom.*

(e) Aristotle, *Physic.* L. 8. c. 5.

planets to be turned round about the Sun by the power of the Sun, yet at last we must find out a mover of the Sun itself, and those other primaries: a cause of sufficient power to wheel about those prodigious masses, of such vast bulks, as have before been assigned to them, and which, besides their own weight, are, according to the former hypotheses, clogged and encumbered with the *vis inertiae* of all those planets whether primary or secondary, or both, which they drive round. And if this was the case, what power can be found sufficient for this work, but that of the same infinite hand that at first gave them being!

And so for all the rest of the moving bodies of the Universe, such as Comets, the new Stars before spoken of (w) and the slow motion of the firmament, or fixt Stars in 25920 (x) years. This latter I shall say no more of,

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(w) Book II. chap. 3.

(x) Ptolemy made this motion to be one degree in 100 years. But others since make it to be more. Mr. Street, in his Caroline tables, makes it 1. gr. 20 minutes: Hevelius 1 gr. 24 minutes. 46 seconds. 50 thirds: but Mr. Flamsteed agrees Riccioli's numbers to come nearest the truth, viz. 1 gr. 23 minutes. 20 seconds. in 100 years, or 50 seconds in a year. According to which rate the motion (called the Platonic year) is accomplished in 25920 years.

because it may not arise from any motion of the firmament itself, but from some other cause(y). But for Comets, what power but that of the Almighty could give them such prodigious projections, as their trajectories or orbs are found to have? Orbs that run into such amazingly long ellipses as approach to *Parabola's*, that 'tis wonderful how their projective force should carry them to such immense distances, and their gravity at the same time bring them back and incomparably retain them in their orbs.

And so for the new Stars, which I have said are so many signals of planetary systems dispersed here and there all over the Universe, they are all of them so many manifestations and demonstrations of an infinite Being that hath imparted motion unto them: and they are a sign also that there are other globes besides the Sun and its planets, which are moving bodies, even that all the globes in the Universe are such, and consequently so many proofs of an *Almighty first Mover*.

(y) *Sir Isaac Newton demonstrates how this may arise from the Sphaeroidal figure of the earth. Princip. L. 3. Prop. 21. et L. 1. Prop. 66. Corol. 20. See the matter also more easily demonstrated in Dr. Gregory's Astron. L. 1. Prop. 64.*

Thus the bare motions of the earth, and of the heavens are so many arguments of a Divine power therein concerned. But we shall moreover find an infinitely wise, as well as Almighty power herein transacting, by what follows in the next chapter.

C H A P. II.

The great Regularity of the Motions of every Globe.

HA V I N G in the preceeding chapter shewn that the giving motion to such immense, lifeless globes, is the work of God, we shall find much greater demonstration thereof if we consider that those motions are not at random, in inconvenient lines and orbs, but such, as shew wise design and counsel. I shall here specify but two examples, because I shall have occasion to say more of this matter hereafter. One is, That all the *Planets* should (when their motions were imprest upon them) have their directions or tendencies given, not in lines tending from the center to the circumference, or very obliquely, but perpendicular

to the *Radii*. The other is, That the motions and orbits of the planets should not interfere with one another, but tend one and the same way, from west to east, and lie in planes but little inclined to one another, or when inclined, that it should be very beneficially so, as I shall hereafter shew. These and many other instances, and in a word, that every planet should have as many, and various motions, and those as regular, and well contrived and ordered, as the world and its inhabitants have occasion for, what could all this be but the work of a wise and kind, as well as omnipotent CREATOR, and ORDERER of the world's affairs? A work which is as plain a signal of GOD, as that of a clock, or other machine is of man. Thus Tully's Stoick (a) argues our present case from the shepherd at Actium, when from the top of an hill, he happened at first to see a ship sailing in the sea, he was for a while in great amazement, and surprize, to see such a moving inanimate body, and could not imagine of what a nature it was possible it should be, until he perceived, by some tokens, that it was made and managed by man. "So,

(a) De Natura Deorum L. 2. c. 35.

“ *saieth he*, the philosophers ought to have
“ done, if haply they had any doubts at the
“ first view of the world: afterwards when
“ they should behold its determined and equal
“ motions, and all things managed by establi-
“ shed orders, and with immutable constancy;
“ they ought then to understand that there is
“ not only some inhabiter in this heavenly, this
“ Divine house, but also some ruler and
“ Moderator, and in a manner, Architect of
“ so great a work, so noble a performance.”

This conclusion is so natural, so cogent, that any thing but stupid prejudiced blockheads (as those philosophers were) would have naturally and easily made it. “ But now, *saieth the*
“ Stoick, (c) they seem to me not so much
“ as to have any suspicion of the wonderful-
“ ness of the things of the heavens or the
“ earth.” And great reason the Stoick had for his surmise. For so manifest a demonstration of a Deity, are the motions of the heavens and earth, that if men do not see them, it is a sign of great stupidity; and if they will not see, and be convinced by them, it is as plain a sign of their prejudice and perverseness, as

will farther appear by considering what an incomparable provision is made for the world's good, by the particular motions which are given to the earth and heavens, namely the *Diurnal* and *Periodical* motions.

C H A P. III.

Of the Diurnal Motion of all the several Globes.

AS to the *Diurnal Motion*, there is great probability that our earth, and all the heavenly bodies have a rotation round their several axes; not all performed indeed in the same space, or length, of time, but some in longer, some in shorter, times; each time making what we call a *day* in those several globes, equivalent, although not equal, to the circumvolution of our earth in twenty four hours.

This diurnal rotation is visible in many of the heavenly globes, and highly probable in our own. In the Sun it is very manifest from the equable motion of its spots, which sometimes appear in its disk, and have been observ-

ed formerly by Galilaeo (a), Scheiner (b), Tarde (c), Malapertius, Hevelius (d) and our countryman, Mr. Gascoigne and Mr. Crabtree (e); and since them by Mr. Boyle, Dr. Hook, Dr. Halley, Mr. Flamsteed and others in England, and by Messieurs Cassini,

(a) *Galilaeus tells us in the third dialogue of his system. Mund. that he was the first that discovered spots on the Sun, in the year 1610, which he shewed the next year to divers great persons in Rome. That Scheiner sent him two letters by Velserus under the feigned name of Apelles, to desire his opinion of them, that he concluded them to be alterable, contrary to the received opinion then, of the heavens inalterability, that they were contiguous to the Sun, and that their path over the Sun, sometimes in a curve, sometimes a strait line, argued the annual motion of the earth about the Sun, and not of the Sun about the earth; with more to the same purpose, which may be seen in the sagacious Author in his first and third dialogues.*

(b) *Vid. Scheiner's Rosa Ursina.*

(c) *Vid. Tarde's Astra Borbonia, who took 'em to be small Stars interposing themselves between the Sun and us. Of the same opinion also was Malapertius, who gave them the name of Sydera Austriaca.*

(d) *See Hevelius's opinion of them at large in his Selenography, ch. 5. and in the Appendix.*

(e) *In their letters, now in my hands, there is an ingenious controversy between those two great men, Mr. Gascoigne, the inventor of the Micrometer, and Mr. Crabtree, concerning the Solar spots that appeared about the year 1640. which Mr. Gascoigne imagined to be great numbers of small planets revolving round the Sun at a small distance from him. Mr. Crabtree's answer and opinion may be seen in his letter which is published with my own observations about the Solar spots from 1703 to 1711 in the Philos. Transf. No 330.*

Picart, and others abroad (f), and of late by myself and others too. These spots have manifestly a motion, and the same motion too, as that of a globe moving round upon its poles: for we may perceive them to be perpetually shifting their places from the Eastern to the Western limb of the Sun; and in this doing, their daily stages and motion exactly correspond to the motion of a globe; that is, those stages are shorter, and the motion of the spots seemingly slower towards the Sun's limb, but near the center of the disk, larger and swifter and all in exact proportion to a double line of sines, or a line of sines on each semidiameter of the disk.

And farther yet, these Solar spots, as they manifestly demonstrate the Sun to be a moving globe, turning round once in somewhat above 25 days, so they manifest themselves to be something adhering unto, or nigh the Sun's globous body, by means of the different appearance they have in the different parts and positions of the Sun: as in the middle of the disk, if they are round, towards the limb they become more and more oval or long, just as

(f) *The observations of those great men which are dispersed about in the Phil. Transf. may be seen at one view in Mr. Lowthorp's Abridgment, Vol. 1. p. 274.*

such a like spot on a common globe would appear when it is turned so as to be viewed by us sideways or going out of sight.

And lastly, another thing observable in and from these spots is that they describe various paths or lines over the Sun, sometimes strait, sometimes curved towards one pole of the Sun, sometimes towards the other, exactly corresponding to the different positions of the earth, in respect of the Sun throughout all parts of the year.

Thus in that vast mass, the Sun, we have manifestly such a diurnal motion as I spake of, or circumvolution round its axis; a motion constant and regular, and doubtless of as great use to some office or other, in some part or other of the Universe, as the motions of the earth, are to the inhabitants thereof: and a motion therefore this is, demonstrating the concurrence of the Almighty.

Neither is it the *Sun* alone that undergoes a *diurnal rotation*, but most, if not all the erratics about him. *Saturn* indeed is at so great a distance from us, that we have not been able to perceive whether or no he hath such a rotation; but as the other planets have it, and there

is full as much occasion for it in *Saturn* as in them, so there is no great doubt to be made, but that he hath such like a diurnal motion, accommodated as well to his state, as it is in the earth and the rest of the planets.

So *Jupiter* is discovered to have manifestly a motion round upon its axis from east to west, in the space of 9 h. 56, as *Monf. Cassini* (g) by many repeated observations in the year 1665, and other following years, first found, from the spots observable on it; of which there are two kinds, which I my self have often seen as well as others before me, a short account of which (although it be a digression) may not be unacceptable to many readers. One kind of these *Jovial Spots*, is only the shadow cast upon the planet by the *Satellites* intercepting the light of the Sun; when they are interposed between the *Sun* and *Jupiter*: the other are such as are really in the body of that planet, after the manner of those we see in the Moon, but not permanent as they are. And by the motion of these latter spots it is manifest, not only that *Jupiter* revolves round in the time mentioned, but that it is a moving

(g) See his observations in the memoirs de Mathem. et de Physique for Jan. 1692.

globe also, by reason (as was said of the Sun) those spots move swifter, and in larger stages towards the middle, than towards the limb of *Jupiter's* disk. Also such spots as are round, about the middle, appear long or oval towards the limb, or edge of the disk; as was before observed of the Sun's spots.

As to *Mars* and *Venus*, they are both discovered to have spots, or parts lighter and darker, as well as *Jupiter*, and to have a motion also as he hath. Of those spots in *Mars*, Dr. Hook had divers views in the year 1665, which he hath given us figures of (h): and from thence concluded that planet had a motion, although he could not determine in what time it was performed. But Mr. Huygens expressly saith (i) it is performed in the space of 24 h. 40. But for the motion of *Venus*, Monf. Cassini could perceive the spots to change their place, and that the planet had a motion, although he could not make out what it was (j).

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(h) See *Philos. Transf.* No. 11, 14.

(i) *Cosmotheor.* p. 24.

(j) Mr. Cassini's observations dispersed in the *Phil. Transf.* may be seen at one view in Mr. Lowthorpe's *Abrige* Vol. 1. p. 383, and 425.

Thus are the primary planets discovered to have a *diurnal rotation*, or somewhat very like it at least, all except *Saturn*, as I said, and *Mercury*, and our own globe. And as to these we have very little, or no reason to imagine but that they move as well as the rest; only we cannot perceive it in *Mercury*, by reason of its proximity to the Sun, and that its elongations are never so great, nor so long, as to enable us to have any good and sufficient views of him with our telescopes.

And as for our own globe, it is very visible that either that moves round in 24 hours, or that the Sun and all the heavens move round it in the same time. And which of these two is the most agreeable to the usual course and methods of nature, which performs all its works in the most compendious, facile way, let every one judge. And is it not far the most compendious, ready, and easy way that the terraqueous globe should wheel about in 24 hours, than that so many vast bodies of the heavens should be turned about it in that time? Is it not as possible, yea as probable, that our lesser globe should be so turned about, as those more massy globes of the *Sun*, *Saturn*, and *Jupiter* are about their axes? But I shall not enter into a detail of the

arguments for the earth's motion, and the objections made against it, because I have done it in the preliminary discourse.

Thus having taken a prospect of the *diurnal motions* of the great globes of the Universe, that fall best under the cognizance of our instruments, and found that many, and probably all of them have a rotation round in a determinate time; if to this we add the *convenience* and prodigious *use* of this motion to the several respective globes, we shall find that an infinitely *wise* and *kind*, as well as *omnipotent Being* was the *orderer* thereof. For were those globes always to stand still, especially the *eratics*, that owe their light and heat to the Sun, in this case, one half of them would be dazled and parched with everlasting day, whilst the other would be involved in everlasting night and darkness. And what the consequences would be, we may best judge from what would befall our own globe, without the kindly alterations of day and night: and that is, that it, at least a great part of it, would scarce be habitable, it would neither agree to the state of man, or any other animals; nor to that of

vegetables, or indeed any other creature. For one half of the globe would be burning up, at least too much drying, and exhausted with the beams of the Sun, whilst the other would be immersed in, and deadned with too long night. And in such a case, how could the great works of nature, so serviceable to the world, be performed? How, for instance, could the vapours be raised to supply the earth with cooling clouds and fertile showers? How could the winds be excited to fan the atmosphere with their pleasant and healthful gales? How could the tides be produced, which by their constant agitations keep the waters sweet and clean, and prevent their poisoning the world?

And as the course and functions of nature, would be thus affected, so would the state of the creatures be no less. For how could those of the vegetable kingdom be animated and excited by the kindly heat of the day, and then again tempered and invigorated by the no less kindly dews, and influences of the night? How could men and all other animals dispatch their business, gather their food, and perform all the various labours and offices of the day, and

then recruit and repose themselves with rest, sleep, and due perspiration, and whatever else may be owing to the salutiferous influences of the night, and absence of the Sun?

These and ten thousand as great inconveniencies as these, would be the certain events of the want of this diurnal motion of our globe. And as the rest of the globes have their shares in the like motion, so we may very reasonably imagine that it is no less useful and beneficial to them than it is to us, and that the inconveniences of the want of it would be as great.

C H A P. IV.

Of the Annual or Periodical Motion of the Primary Planets.

BESIDES the motion treated of in the preceeding chapter, there is another, which is as clear a manifestation of the great CREATOR as that, namely the *Periodical* or *Annual*, which is visible in some of the great globes, and probable in many others. Among the fixt Stars it is highly probable

something of this nature is: as appears from those new Stars which I have before taken notice of, which, as I have said, sometimes become visible to us, in one part of their orbits, and again disappear in other parts of them. But these systems being out of the reach of our best glasses, I shall pass them by, especially because in our own solar system we have abundantly enough to entertain us in this demonstration of GOD.

For it is very visible, without the help of the telescope, that every *Planet* of the *Solar System* hath this *Periodic motion* I am speaking of. For it is manifest that either the Sun, and the Planets move about the earth, the one in the space of a year, and the rest in other times; or that the earth and the other Planets move about the Sun in such times. But let us (as I have all along done) suppose the latter, that the Sun is fixt in the center, without any other but its diurnal rotation in $25\frac{1}{4}$ days: in this case we shall have the several primary Planets revolving round the Sun in an excellent and due order, by the exactest rules of such a noble structure, such an admirable Oeconomy, and that is 'in times (as I said) in square pro-

‘portion to the cubes of their distances.’ So that we see *Mercury* to perform its period in near 88 days: *Venus* (the next in order to the Sun) its period in somewhat above 224 days: then the *Earth* with its companion the *Moon* in 365 days and one fourth: then *Mars* in about 687 days: next him *Jupiter* in about 4333 days: and lastly *Saturn* in somewhat above 10759 days.

To this so strict an order of the *periods* of those Planets, we may add the consideration of the different *paths* of their *Periodical* and *Diurnal motion*: that they lie not in a very different plane, as quite across, or the like; nor exactly in the same plane, but a little crossing one another; the Diurnal course lying in, or parallel to the Equator; but the other in the broad path of the Zodiac at an inclination of 23 one half degrees.

And a glorious contrivance this is for the good of our globe, and doubtless no less for all the rest that sympathize in the like motion. For was the earth’s Periodick motion to be always in the same plane with that of the Diurnal, we might indeed be sometimes nearer to, and sometimes farther from the Sun; but at the

same time miss of those kindly increases of day and night, together with such useful directions of the Sun-beams, which the advances of the earth to one or other of the poles cause (a): which two things are the real causes

(a) *There are two causes of the great difference between the winter and summer, heat and cold. One is the shorter or longer continuance of the Sun above the Horizon: in summer long, which increaseth the heat, as much as it lengthens the day: in winter short, which diminishes the heat, as it shortens the day; and augments the cold, as it lengthens the night. The other cause is the oblique or perpendicular direction of the Sun's rays, the oblique being weaker than the perpendicular; as is evident from Galileo's experiment, in his system. Mundi, Dial. i. by holding a paper turned up at right angles, or a book half open; over-against an illuminated white wall; where it may be observed that the side opposite to the wall, which the rays strike perpendicularly, is far more light and white than the other side, on which the rays fall obliquely. The same it is in the incidence of the Sun's rays on any plane, namely the rays are so much stronger, and the plane the more warmed and enlightened, as the rays are more or less perpendicular; and that on two accounts; 1. Because the perpendicular rays strike with greater force than the oblique. As in Fig. 4. the rays RR strike the plane AP more forcibly than the plane OB . The action or force of which percussion is (like that of all other impulses) as the sine of the angle of incidence. So the force of the rays RR upon the oblique plane OB , is as the sine only of ROB , whereas their force upon AP is as the whole sine of 90 . degrees or angle ROP . 2. Another reason is, that a greater number, or quantity of rays, fall within the compass or area of any plane, in a perpendicular, than oblique direction.*

of our seasons of summer and winter, spring and autumn, and not our being nearer unto, or farther from the Sun. For those benefits (we at least that inhabit towards the Northern Pole) have at the contrary season, when we have most need of them, *viz.* the Sun's proximity in winter; its greater distance from us in summer; as is manifest from the increment of its apparent diameter in winter to 32 minutes,

This will be manifest from the bare inspection of Fig. 4. Where it may be observed that all the rays between $R R$ and $O p$ fall on the plane AP ; but only about one half of them would fall upon an oblique plane of the same length, if it was $O b$; or (which is the same thing) near as many rays would fall off $O b$, turned up to $O b$, as fall upon it. Also it may be observed farther, that as the line $O B$ is longer than $O p$, so are the spaces between the rays larger in $O B$ than $O p$; and consequently fewer rays fall on $O B$ for its length, than on $O p$ for its length, or the rays are denser, or more compact in $O p$ than $O B$. And when they are so, they are so much the stronger, as is evident from the collecting and condensing the Sun's rays by a burning glass.

*What the particular power of the Sun's rays is in all directions, quantities, and impulses, falls under mathematical calculation; but I need not trouble the reader with it, but shall refer to the ingenious Dr. Wolsius, Mathematical professor of Hall, his *elementa Aerometriae*. And as for the proportional degree of the Sun's heat in all latitudes, and its altitudes, our most acute Savilian Professor, Dr. Halley, hath given us a neat and clear method for computing it in *Philos. Transact.* No. 203.*

47 seconds, and the decrement thereof in summer to 31 minutes, 40 seconds. (b)

And now for a conclusion of this chapter concerning the Periodic motions of the primary planets, we may take up the argument of Hugo de S. Victore (c), “Who commandeth
“ the Sun to descend through the winter signs?
“ And who again causeth him to ascend through
“ the summer signs? Who leads him from
“ east to west? and who again brings him back
“ from the west to east? All these things are
“ very wonderful, but to God alone possible.”

(b) *Monsieur de la Hire in his Tabul. Astron. makes the Sun's semidiameters to be Dec. 30. 16 minutes 22 seconds, and Jun. 30. 15 minutes, 49 seconds. But Mr. Flamsteed in his Lunar Tables added to Mr. Horrox's Posthumous works makes the greatest to be 16 minutes 23 seconds, the least 15 minutes, 50 seconds; and the French Academists 16 minutes, 23 seconds; and 15 minutes, 50 seconds. Vid. Recueil d' Observ. Les Elemens d' Astron. p. 22.*

Besides the alteration of the Sun's apparent diameter, its swifter motion in winter about the solstice by about a 15th part, is an argument of its being then nearer the earth. From whence it comes to pass that from the Vernal to the Autumnal Æquinox, there are about 8 days more, than from the Autumnal to the Vernal.

(c) Quis solem per hyberna descendere signa præcipit? Quis rursus per æstiva signa ascendere facit? Quis eum ab oriente in occidentem ducit? Quis iterum ab occidente in orientem revehit? Haec cuncta sunt mirabilia, sed soli Deo possible. Didascal. L. 7. c. 8.

C H A P. V.

Of the Periodical Motion of the Secondary Planets.

HA V I N G considered the periods of the *Primary Planets*, let us next cast our eye upon those of their *secondaries*. And among these we shall find the same compleat order and harmony as among the last. Thus *Saturn's* five moons and *Jupiter's* four, and our own about the *Earth*, have each of them their determinate times, some longer, some shorter intervals of time, in the same due proportion, as I spake of among the primaries.

Besides which, there is another thing very considerable in this periodical motion of those secondary planets, and that is, that it is mixt with a kind of *cochleous* direction towards one or other pole of the primary planets ; by which means every *satellite*, by gentle degrees, makes its visits towards each pole of its *Primary*. This is well known among the *Circumjovials* for instance, that they all have a slow and gradual screw like progress, first towards one, then back again towards the other pole of

Jupiter : and that each *satellite* hath its declination greater and greater, according as it is farther or farther from *Jupiter's* body. Accordingly the declination of each *Circumjovial*, assigned by the diligent and sagacious Cassini (d), after twelve years observations, are these, The greatest declination of the *First, or nearest*, exceeds not a third part of *Jupiter's* semidiameter: that of the *second*, surpasseth but a little of a quarter of its diameter: that of the *third* a little exceeds three quarters of the diameter: and that of the *fourth, or outermost* goes beyond *Jupiter's* poles by a third part of the semidiameter. All which mutations, he saith, are performed in the space of 12 years. Thus the famous Cassini. But I have myself observed a greater vagation in the *Third Satellite*; that it advanced near to, if not even with the very limb or pole of *Jupiter*, and that its stay in *Jupiter's* shadow, or the duration of its eclipse at that time, was less than is commonly assigned unto it, as it is reasonable to imagine it should be, because the *Satellite* had only the outside of the cone of *Jupiter's* shadow, and

(d) *Les Hypoth. et les Tables de Satel. de Jupiter*, §. 4. in the French Academist's large Collection.

consequently a lesser part thereof to pass thro' at that time.

As to the end and use of this so observable a tendency in the secondaries towards each pole of their Primaries, we may guess at it from what hath been said of the like tendency of their primaries towards the Sun, on which our seasons do depend: So those secondaries, moving in like manner to each pole, effect some of the grand works of the Divine providence from pole to pole, illuminate all parts of their respective globes, contract the length of their nights (as shall be shewn in proper place,) move their waters, and excite their tides, and perform other such great works of nature, as with good reason, we attribute to the influx of our Moon here in our own globe.

And can such well-contrived, such useful motions, that the world could not subsist without, that nature could not do its grand works without, can these be other, than the *Fiat* of an infinitely *indulgent*, as well as *wise* CREATOR! Could this consonancy be so universal, among all the globes that fall within our view? Could their periods, and distances, be in the same due proportion all the Universe over,

their motions all so alike, had they not had the same *Contriver* and *Maker*! But I shall close this argument with the reflection of the most ingenious Mr. Molyneux (b), who speaking of the sesquiplicate proportion of both the primary and secondary planets, thus concludes.

“ And from hence we may justly fall into the
“ deepest admiration, that one and the same
“ law of motion should be observed in bodies
“ so vastly distant from each other, and which
“ seem to have no dependance or correspon-
“ dence with each other. This doth most
“ evidently demonstrate that they were all at
“ first put into motion by one and the same
“ *unerring hand*, even the infinite *Power* and
“ *Wisdom* of *God*, who hath fixed this order
“ among them all, and hath established a law
“ which they cannot transgress. Chance or
“ dull matter could never produce such an
“ harmonious regularity in the motion of bo-
“ dies so vastly distant: this plainly shews a
“ design and intention in the first Mover.
“ And with submission to the reverend and
“ learned Divines, I am apt to think that one
“ argument drawn from the order, beauty and

(b) *Dioptr. Nov. Par.* 2. c. 6. §. 12.

“ design of things, is more forcible against Atheism, than multitudes of notional proofs.” Thus Mr. Molyneux. But we shall find farther evidences of this *Supreme management* in these matters from what follows in the next chapter.

C H A P. VI.

The Constancy and Regularity of all the Motions of the Earth and Heavens.

THAT the earth and heavens move at all, but especially that they have such particular and beneficial motions, appears, from the preceeding chapters to be the work of God. And the concurrence of the same infinite hand is as manifest in the perpetuity, constancy, and regularity of those motions. For without this Almighty Guide and Manager, how is it possible that all those vast and unwieldy masses should continue their beneficial motions throughout all ages? should perform their useful stages without any the least intermission, interruption or disorder that we know of? What motion, what contrivance,

what piece of clock-work was there ever under the whole heavens, that ever came up to such a perfection, and that had not some stops or some deviations, and many imperfections? But yet none was ever so stupid as to conclude such a machine (tho' never so imperfect) was made by any other than some rational being, some artist that had skill enough for such a work. As he in Cicero (a) argues from his friend Posidonius' piece of watch-work, that shewed the motions of the Sun, Moon and five Erratics; that if it had been carried among the Scythians or Britains, "Quis in illa barbarie dubitet, quin ea Sphaera sit perfecta Ratione?" with more to the same purpose: no man even in that state of barbarity would make any doubt, whether it was the workmanship of reason or no (b). And is there less reason to imagine those motions I have been treating of to be other than the works of God, which are infinitely more constant and regular than those of man? Or, to use the last mentioned Stoic's argument, can it be thought that Archimedes "was able to do more in imitating the motions

(a) *De Nat. Deor. L. 2. c. 34.*

(b) *See the place cited at large in my Physico-Theology, p. 2.*

“ of the heavens (*in his sphere*) than nature
“ in effecting them ?

And now to reflect upon the whole, and so conclude what hath been said concerning these several motions: We may all along perceive in them such manifest signals of a Divine hand, that they all seem, as it were, to conspire in the demonstration of their infinite CREATOR or ORDERER. For besides what in all probability is in other parts of the Universe, we have a whole system of our own, manifestly proclaiming the workmanship of its *Maker*. For we have not those vast and unwieldy masses of the Sun, and its planets, dropt here and there at random, and moving about the great *expansum*, in uncertain paths, and at fortuitous rates and measures, but in the compleatest manner, and according to the strictest rules of order and harmony; so as to answer the great ends of their creation, and the divine providence; to dispatch the noble offices of the several globes; to perform the great works of nature in them: to comfort and cherish every thing residing on them, by those useful changes of day and night, and the several seasons of the year.

These things are so evident to the reason of all men, that Tully might well make his Stoic to alledge this as one of his principal arguments for the proof of a Deity (c): “ The
“ fourth cause, *saith he*, and that even the
“ chief, is the equality of the motion, and the
“ revolution of the heavens; the distinction,
“ utility, beauty and order of the Sun, Moon,
“ and all the Stars; the bare view alone of
“ which things is sufficient to demonstrate
“ them to be no works of chance. As if any
“ one should come into an house, the Gymna-
“ sium, or Forum; when he should see the
“ order, manner, and management of every
“ thing, he could never judge these things
“ to be done without an efficient, but must
“ imagine there was some being presiding over
“ them, and whose orders they obeyed. So
“ much more in so great motions, such vicif-
“ situdes, and the orders of so many and
“ great things;---a man cannot but conclude,
“ that such great acts of nature are governed,
“ by some mind,” some intelligent being.

And so again afterwards (Chap. 21.) when, among other things, he had been speaking of

(c) *De Nat. Deor. L. 2. c. 5.*

the motions of the planets, he thus argues,
“ I cannot possibly understand, *saith he,*
“ how all this constancy can be among the
“ Stars; this so great agreement of times
“ through all eternity, among such various
“ courses (*how this can be*) without some mind,
“ reason and counsel.” And a little after
this, speaking of the fixt Stars, he saith,
“ But the perennial, and perpetual courses of
“ those Stars, together with their admirable and
“ incredible constancy, declare a Divine power
“ and mind to be in them.” And this he takes
to be so plain a case, that he who could not
discern it, he thinks could discern nothing.
And then he thus concludes, “ In the heavens
“ then, there is neither any chance, nor any
“ temerity, nor error, or vanity; but on the
“ contrary, there is all order, truth or exact-
“ nefs, reason and constancy. And such things
“ as are void of these are counterfeit, false,
“ and full of error.—He therefore that thinks
“ the admirable celestial order, and incre-
“ dible constancy, on which the conservation,
“ and good of all things depend, to be void of
“ a mind, he himself deserves to be account-
“ ed devoid of a mind.” Thus with great

force and reason, Tully's Stoic rightly infers the presence and concurrence of a Divine Being, and power, from the motions of the heavens: only not being aware who that Being was, he erroneously imagines the heavenly bodies themselves to have Divinity, and puts them therefore into the number of the Gods; which error is excellently refuted by Lactantius in his *Instit. Divin.* L. 2. c. 5, &c.



B O O K V.

Of the FIGURE of the several GLOBES of
the U N I V E R S E.

C H A P. I.

*The Consonancy of all the Globes in their
Spherical Figure.*

HA V I N G in the preceeding book manifested the *motion* of the earth and heavens to be the contrivance and work of GOD, I shall enquire in this, whether their *figure* be of the same kind, wisely suited to the motions, and in a word, to the whole state and convenience of the several globes, so as to manifest itself to be the work of God?

Now as to the *figure*; it is observable in the first place, that there is a great consent therein, among all the globes that fall under our view, and that is, that they are all Sphaerical, or nearly so, namely Sphaerodical (a). Thus all the fixt Stars, so far as we are able to behold them, either with our naked eye, or our glasses. Thus the Sun, and thus all its planets; and thus the secondaries, or

(a) See *Physico-Theol*, B. 2. C. 1. Note a.

Moons accompanying *Saturn*, *Jupiter*, and our *Earth*. And although *Venus*, *Mercury*, and our *Moon* have *Phases*, and appear sometimes falcated, sometimes gibbous, and sometimes more or less round, and even *Mars* too, in its quadratures, becomes gibbous; yet at such times as these planets shew their full phases, they are found to be spherical, and only lose this figure by virtue of their position to the Sun, to whom they owe their light. And this sphericity, or rotundity, is manifest in our *Moon*, yea and in *Venus* (b) too; in whose greatest falcations the dark part of their globes may be perceived, exhibiting themselves under the appearance of a dull and rusty colour.

(b) *What I have here affirmed of the secondary light of Venus, I have been called to an account for, by an ingenious Astronomer of my acquaintance. But I particularly remember, that as I was viewing Venus some years ago, with a good 34 foot glass, when she was in her perigee, and much horned, that I could see the darkned part of her globe, as we do that of the Moon soon after her change. And imagining that in the last total eclipse of the Sun, the same might be discerned, I desired a very curious observer that was with me, and looked through an excellent glass, to take notice of it, who affirmed that he saw it very plainly.*

And as this spherical figure holds in every of the globes at a distance from us, so we may reasonably imagine our own globe to be consonant to the rest. But indeed we have great reason to conclude it to be so from the curvity of its shadow in its eclipses of the Moon; from the discovery of new constellations in the heavens, as we change our hemisphere, and make approaches towards either pole; from the surface of the sea, which appears to be of this figure, by our gradually discerning far distant objects, mountains, towers, sails of ships, &c. the parts of which are more and more seen, as we approach nearer and nearer to them: with other arguments to the same purpose, which I need not enumerate in a case now generally owned to be true.

C H A P. II.

Of the Inequalities, or Hills and Vales observable in the Earth and Moon.

HAVING in the preceeding chapter demonstrated the several globes of the Universe to be spherical, it is not to be understood that these globes are strictly so, but an

allowance is perhaps to be made for the difference between their Æquatorial and polar diameters, before spoken of: but especially for those little and inconsiderable excrescences of the hills, very manifestly discernable in the Moon (a), as well as in our own globe; which

(a) *Every one that hath viewed the Moon with but an ordinary glass, especially, when she is not round, may easily perceive considerable unevennesses; that some parts are manifestly higher and others lower. About the quarters, diverse bright golden spots may be seen in the shaded part, at some distance from the enlightned part; and these may be perceived to grow larger and brighter, as the shady part turns more and more towards the Sun; till at last you may see all the intermediate vallies between those spots, and the other enlightned parts. Also in divers parts of the Moon, especially such as border on the shaded part, there may be observed to be certain holes or pits, black, dark, or shady, when the parts encompassing them are illustrious and bright. And this darkness, as if under some mountain, lies always on the side next the Sun, and gradually goes off as the hole, pit or valley turns more and more towards the Sun, till at last the whole valley is enlightned, and looks like a depressed ground in the body of the Moon. All which things are manifest signals that the Moon's surface is not even and smooth, but like that of the earth, full of hills and valleys.*

Which opinion, altho' now well grounded on ocular demonstration, was as old or older than Plutarch's days, who in his book de Facie in orbe Lunae, at the beginning, cites it as Clearchus' opinion Εικονας εσοπτρικας ειναι τα ειδαλα της μεγαλης θαλασσης—i. e. That which is called the face of the Moon, are the images and appearances of a great sea in the Moon. And about the middle of that tract; Τα δε φαινομενον τουτ' προσωποι—i. e. As to that face which

I call little and inconsiderable, especially those in the earth, because they are so in proportion to the earth's diameter; as will appear by coming to particulars. The Diameter of the terraqueous globe I have shewn in my *Physico-Theology* (b) to be about 7935 English miles, and in this book to be (*) 7967 miles: but that of the hills is no more than a few miles. *Snowdon* in *Caernarvonshire* (the highest mountain in all our island) is but 1247 yards (c); the Alps themselves but about two English appears in the Moon: as our earth hath certain large bays; so we conceive the Moon is over-spread with large hollows and ruptures, containing water, or a thick dark air, into which the Sun-beams are not able to enter, and so no reflexion is made by them.

As to other matters in which the Earth and Moon seem to agree, as in seas, and great collections of waters, an atmosphere, &c. I shall pass them by here, as improper for this place.

(b) *Book 2. ch. 2. Note.*

(*) *Book 1. ch. 2. Note a.*

(d) *In the Journal of the late ingenious Richard Townley Esq; of Townly in Lancashire, I find this Note upon Sept. 6. 1682. This day Mr. Adams called here, who is taking a survey, &c. He told us that with repeated trials he had found Snowdon-hill 1320 yards higher than the highwater-mark, and that the quicksilver stood at the bottom at 29 inches; at the top of the hill 25.96: so that 1320 gave 3.04. Then follows this Note, viz. Mr. Adams coming since tells me, that the height of Snowdon was but 1247 yards, which gave 3.04.*

miles (d): nay the very *Pike of Tenariffe*, one of the highest ridges throughout the globe, unless we except the high mountains of *Peru* called by *Jos. Acosta* (e) *Periacaca*; or that nearer *St. Martha* (f); or those called the *Andes* (g); this ridge (I say) is computed to be but between 3 and 4 Miles perpendicularly above the Sea (h). All which eminences, compared with the diameter, or semidiameter of the earth, is no more than as a particle of dust is to a large globe, on which it resteth.

The reason of this difference of 73 yards, in the height of Snowdon, I take to be, that the first measure was made by Mr. Adams himself, the latter by Mr. Casewell with Mr. Adams' instruments: and probably the former is the height above the sea, the latter only above some plane.

(d) *Mr. Nic. Facio told me that he had measured the height of the Montaigne Mauditi, which is one of the highest ridges of the Alps, and that he found it to be 2000 French Toises above the lake of Geneva, which is equal to 12816 English feet, or 2. 42 miles.*

(e) *Acosta saith the Alps seemed to these mountains he travelled over, but as ordinary houses to lofty towers. See my Physico-Theol. B. 1. c. 1. Note b.*

(f) *Capt. Dampier saith that he was of opinion, that the hill near St. Martha is higher than the pike of Tenariffe. Voyage round the world. p. 24.*

(g) *Of the Andes of Chili and Peru, Capt. Dampier saith, These are the highest mountains I ever saw, far surpassing the Pike of Tenariffe, or Santa Martha, and I believe any mountains in the world. ibid. p. 95.*

(h) *See Dr. Hook's account of the Pike of Tenariffe; from his friend Mr. G. T. who went to the top of it; at the end of his lectures concerning springs. p. 42.*

And so likewise for the mountains visible in the Moon, although some of them are of that height (i), as to reflect the light of the

(i) By Riccioli's measures, the height of what he calls mount Sinai, or St. Katherine's hill, is 9 Bononian miles, and that of Xaverius 12, but according to his corrections, the former is but 8 miles and fourteen 25ths, the latter 11 and one half. Which at the rate of 6020 English feet in a Bononian mile, is about 13 and 9 English miles; an height so great, considering how much the Moon is less than the Earth, that I cannot but think that diligent person was mistaken in his measures, and that the computations of Hevelius are much the best: who as he was as able as any man, and made more accurate and diligent observations of the Moon's face, than most men ever did; so he was more likely to come nearest the truth. And by this reckoning, the highest hills in the Moon are but about three quarters of a German mile; and some of them but seven sixteenths; and some not above one Italian mile. And considering the bulk of the Moon to that of the Earth, these are great eminences for the Moon.

And as the lunar mountains are of so prodigious heights, so many of them are of great extent. Hevelius reckons the lunar Taurus to reach to 170 German miles; mount Sepher 150; and the lunar Apennine above 100 German miles.

The way how to measure the height of the mountains of the Moon, is not difficult, nor uncertain; which is by observing the distance between the distant golden spots, at their first appearance (which are the tops of hills) and the enlightened part of the Moon. Which distance may be computed by miles, or any other equal parts; into which we can imagine the Moon's diameter divided. Thus in Fig. 5. ARB is a part of the Moon's circumference, one part of which AR is enlightened, the other

Sun from their lofty tops some days before ever it reacheth the vallies beneath them, yet on the *Moon's* limb we can discern nothing of them; but so far from that, that, on the contrary, the edge through our best glasses looks like an even, smooth, and uninterrupted circle (k).

part R B is in darkness. H i is a mountain, whose top H is touched by the Sun-beams, shining from S the Sun to R, and reaching to H. Now supposing the semidiameter of the Moon RC, to be 274 German miles, according to Hevelius, the length of the side RH (or distance between the top of the hill, and the edge of the enlighten'd part) will be found also to be a 10th, 20th, or other part of that semidiameter or diameter; or some certain number of miles; and then we have the two sides RC, 274 miles; and RH, and the right angle included between them; by which, both the other angles, and the side CH, may be found by a common case of right-angled triangles. Out of which side CH, deducting the Moon's semidiameter 274, there remaineth the height of the mountain Hi. Consult here Hevel: Selenogr. ch. 8. Galilaeus Nunc. Sider. p. 14. Riccioli Almagest. L. 4. c. 8. Schol.

(k) The edge of the Moon, which I here mean, is that next the Sun; on which I could never perceive with my best glasses any the least sign of a mountain, but all to be exactly level and smooth. Only indeed there are some certain transient roughnesses and unevennesses on the limb caused by vapours, especially when the Moon is near the Horizon, and in windy, and some other weather. At which times, the motion of the air and vapours, make a pretty crispation, and rousing, like waves on the Moon's limb, which have the appearance of moving mountains and valleys. But on the opposite side, if the least portion of the darken'd part of the

Although then vast mountains, when seen near at hand, seem to be very considerable excrescences of our globe, yet since they are little, when compared to the globe itself, we may look upon our own, and all the rest of the globes as if they were perfect spheres, or at least spheroids. And finding them to be such, let us next enquire what reason there is to imagine this their form to have been the great CREATOR's *Work*.

Moon, extends beyond the enlightened part, Mountains may very manifestly be discerned, exactly resembling ours on the earth. A few hours before and after the full, I have with pleasure seen the appearance of considerable mountains and bays. One of which views, I have given in fig. 6. which is the Moon's appearance, soon after the full, on Sept. 12. 1714. In which several risings and depressions may be seen, and the tops of some of the mountains somewhat distant, are expressed by the little spots.

These alone I conceive are mountains which the excellent Hevelius speaks of in several places of his *Selenography*, particularly in his answer to Bettinus, and other *Peripatetics*, in ch 6. p. 143. who denied that mountains could be in the Moon, as well as many other things discovered now by the telescope.

C H A P. III.

The Universality and Uniformity of the Figure of the several Globes of the Universe is a Sign of their being the Work of GOD, not of Chance or Necessity.

W H E N we see divers pieces of curious device and workmanship to bear the same marks of art, to have the same masterly strokes of painting, clock-work, architecture, &c. we conclude with great reason such pieces were made by the same skilful hand. So when we see the same commodious spherical figure to be imparted to the earth, and all the heavenly bodies, we have as good reason to conclude them to be pieces of the same hand, contrivances and works of the same skilful architect. For if the Universe had been a work of *Chance*, all the several globes would have been of several forms, one of this, another of a quite different figure; one square, another multangular, another long, and another of another shape. Or if all the several globes had been a work of *Necessity*, and their figure had been owing to the natural tendency, or gravity of

matter, viz. that the self-attracting power of matter did make all the solids and fluids of all the several globes, as naturally run into a globose form, as a drop of quick silver doth: yet still we may demand, how came matter by this so commodious a power? What made it affect so proper a form but the infinite CREATOR's *Fiat*?

But not to contest that point, but granting *Gravity* to be congenial and coeval with *matter*, without enquiring how it came by that power, and allowing that every globe of the Universe had its form from the self-attracting power of its matter, yet still we have undeniable marks of *final causes*, of *wise order*, and an overruling *power* in the case. For let us imagine our terraqueous globe in its chaotic state; all its matter, every particle of it divided, and floating about, and ready, by its self-attraction, to run together into its natural form, that of a globe: In this hurly-burly, this jumble of unguided nature, made by attraction only, a confused globose mass can be supposed to be formed; but without any order, without that convenient lodgment of its parts, as the necessities of an habitable world require. But instead of any such signs of disorder, or of na-

ture's acting with an unguided power, we have the clean contrary; all the signals of a wise contrivance, and excellent art; as will appear in the following chapter.

C H A P. IV.

The Terraqueous and other Globes appear to be the Work of GOD from the wise Disposition of their Parts.

AS the earth, and all the other globes would have been of various forms, if they had been made by *chance*, or would have been confused masses, if made by *necessity*, according to the last chapter: so in this I shall shew them to be the work of a *wise* and a *kind Agent*, from the commodious structure and disposition of their parts, so far as we have any knowledge of them. Thus the *Moon* hath great appearances of being no less commodiously, than the earth, divided into hills and valleys, (as I have set forth in the second chapter;) into dry-lands, and great collections.

of waters (a), and to be encompassed with an

(a) That there are seas, or great collections of waters in the Moon, is highly probable from the Moon's spots, which plainly seem to be water on these two accounts, 1. Because those spots appear to be in strait and level long planes, when view'd about the Moon's quarters, or at such times as one half of them are enlighten'd, the other half in darkness. In this case, when we do not look directly upon the planes, or see them wholly enlighten'd, but view them in a manner sideways, their surfaces look as the sea doth, when we view it from the shore, viz. a large level plane: only we may now and then discern a bright shining part standing a little out of the large levels, which are, no doubt, certain rocks or islands in the midst of those seas: 2. The darkness of those spots, more than other parts of the Moon, is an argument they are water, or some such like fluid, which imbibes the Sun's rays more than harder bodies, and doth not therefore so vigorously reflect them as they do. Accordingly about the Moon's quarters, when those spots, as I said, have the appearance of long planes, we may observe their edge to be a kind of hazy border, which grows darker and darker, as the rays are more and more absorbed.

But indeed hard bodies, if they have smooth surfaces, altho' they reflect strongly to one place, yet in other places they are less visible. Thus a looking-glass, a diamond, &c. reflect vigorously the Sun's rays towards one part, so as to dazzle the eyes; but in other parts, they appear of a dark, blackish hue. Which by the by, is the reason why Jewellers grind their diamonds with many sides and angles, that their lustre may appear many ways. So silver (as Galilaeo observes, Dial. 1.) when boiled only in Argol and Salt, appears as white as snow; but wherever it is burnished, it becomes obscure. And so he tells us, rightly enough, the Moon would become invisible to us, if its surface was not rough, but sleek and smooth. See also Hevelii Selenogr. ch. 6. p. 151.

atmosphere as we are (b). So *Jupiter*, although at so great a distance from us, hath manifestly, we see, his lighter and darker parts; his belts and spots darker than the rest of his disk. These Mr. Cassini (who longer viewed this planet than any body else) takes to be canals containing some fluid matter, or water, that more weakly reflects the Sun's rays, than the other parts of the planet do, and that they have some resemblance with what happens here upon earth. "(c) For if, saith he, one from on high, in the heavens, should see the earth in some particular situations, the sea, which encompasseth the earth, would appear very like the great southern belt that encompasseth the whole globe of *Jupiter*: the *Mediterranean* sea would make an appearance, not unlike those belts which are interrupted or broken, which we see in this planet: the other seas would make those great black spots, which never alter at all: the continents

(b) That there is an atmosphere about the Moon, see Book 7, chap. 3. Note 1.

(c) *Nouvelles Decouvertes de Jupiter*; par M. Cassini in the *Memoires de Mathem. et de Physique* for January 1692.

and isles would seem like those bright spots that are also permanent: the snows would make those glittering sparkles, (Brilliant) that from time to time disappear, the flux and reflux of the Ocean, and those great inundations that happen sometimes here, would occasion other spots to appear and disappear: the Moon would resemble one of *Jupiter's satellites*: in fine, the clouds of our atmosphere would resemble those broken interrupted belts, and those transitory spots, which often change their size and figure, and have motions of different velocities."

Thus that ingenious, and curious observer. According to whose, not improbable opinion, this planet *Jupiter* hath all its parts orderly placed, as is here upon earth.

And so for the rest of the planets, whose faces exhibit different appearances, of brighter and darker parts, as *Mars* and *Venus* particularly do (d), it is highly probable that there may be such a distribution, such an allotment of parts, as those in *Jupiter*, and which are more plainly visible in our own globe.

(d) See Book 4. ch. 3.

Which brings me to speak particularly of our own globe, of which we have a nearer view, and can plainly see the footsteps of divine Providence, in the wise and orderly disposition of all its parts; which are so distributed, so placed, as may best minister to the several uses and conveniences of an habitable world. Thus for instance, the two grand parts, the solids, and the fluids of the terraqueous globe, instead of being jumbled into one mass, are admirably parted, and as nicely laid in proper places. The earth deposited in useful *Strata*; some for the service of the vegetable kingdom; some for the generation and nourishment of minerals and metals; some for that of stones and fossils; and some for the sweetening and conveyance of the waters. And here it is remarkable, and an argument of wise design and appointment, That all those several *Strata*, or beds, are lodged at proper and convenient depths, and distances from the surface; *that* for vegetables, the uppermost, for every man to cultivate; and this divided into various soils, and moulds, for all the varieties of trees and plants; those *Strata* that contain the minerals, metals, and fossils, at such depths, as to be out of the way, when

they may encumber, or hurt us; but may be come at by us, when we have occasion for them. And as for those *Strata* that convey the sweet waters (e) it is very remarkable, that they are so universal, in all, or most parts of the world; that they consist of such proper pervious matter; that they remain so distinct from, and unmixed with the other *Strata*; and that they lie at such due depths, as either to break out into fountains or to be dug into, for wells. But I shall not enlarge on these matters, having spoken of them elsewhere.

And as this so commodious a distribution of the earth, so that of the waters, is a manifest demonstration of the concern of a *wise agent*, although we should ascribe all that is possible to be ascribed, to the necessities of nature in the formation of the world. For the waters, if we observe them well, are accurately dispersed, and lodged about the world, for the proper offices thereof, in seas, in lakes, in rivers, and in fountains. to satisfy the thirst of animals, to afford them some part of their food, and to minister abundant supplies of vapours for the clouds, the rains, and winds: which

(e) See *Physico-Theol. Book 3. ch. 2.*

supplies must either have failed, or been too abundant, or have been attended with some or other great inconvenience, without such a commodious intermixture of the land and waters.

This Σ *uvaywyn*, as the LXX translate it, this orderly *gathering together* of the waters, is implied in Moses's relation of this branch of the creation. Gen. i. 9. "And God said, let
" the waters under the heaven be gathered to-
" gether unto one place." Where the *Hebrew* word *Ikkavu*, denotes a regular and orderly *gathering of the waters*, as if their allotment had been made, their receptacles had been *marked out by a rule, or a plumb line*, by the CREATOR's fiat.

Thus it is demonstratively plain, that the earth and waters were laid by a wise hand; and therefore whatever concern nature might have in giving a spherical figure to our globe, yet was the CREATOR the principal *agent*, the grand *manager* of the matter.

C H A P. V.

The convenience and necessity of a Sphaerical figure to the good of the Globes, is an Argument they were the Work of GOD.

BESIDES the orderly and commodious placing the parts of the several globes, spoken of in the last chapter, there are still other reasons to ascribe the sphaericality of our own and the other Globes to a *wise Agent*. For besides that this figure is the most agreeable to a world, as being the most capacious; and the most agreeable to a mass in motion, as being at a due distance from the center of motion and gravity; so without this figure there could have been no such comfortable, and agreeable alterations of day and night, of heat and cold, as now there are, but some parts must have been, for too long a time, screened from the kindly approaches of the Sun and Moon, and consequently have lain under too long and uncomfortable a darkness, and been chilled with a miserable cold. And as to our own globe, the winds could not have

given those kindly, and salutiferous agitations to the air, as they do, but they must have been too much retarded, if not wholly stopp'd by the exorbitant angles, and jettings out of other figures. And lastly, the waters, which I shewed to be well intermixed with dry-land, would have had, intolerable confluences; one part too much, another none at all; no vapours, no fountains, no rivers: so that instead of an habitable, well stocked world, far the greater part would have been either a desert, or an unnecessary confluence of water.

Thus having made it evident, that particularly our own globe received its figure by the direction of the infinitely wise *Architect* of all things; we have reason, had we none besides, to conclude the same of all the rest of the globes of the Universe, in as much as they agree with ours in other things as well as in their figure, so far as we have any knowledge of them, and their state. Thus the planets of the Solar system, have their light from the Sun as well as we; they turn round on their own axes, and revolve round the Sun, and consequently have their days and nights, their summers and winters, as well as we; they

have their hills and vallies, as I said, their land and waters, by all the signs that may be, as well as we; and therefore agreeing with our globe in so many of those very things, wherein their figure is concerned, had we none of those reasons I have already mentioned, there would however be great reason to presume the same thing of them, as of our earth, *viz.* that they received their figure from the same wise CREATOR, and that (were we near enough to behold them) they have as manifest signals of it as we have.

B O O K VI.

OF the ATTRACTION or GRAVITY of the
Terraqueous, and the other Globes.

C H A P. I.

The Usefulness of Attraction in the Production and Preservation of the Figure of the Earth, and the Descent of heavy Bodies.

HAVING in the two last books treated of the motions and figure of the globes, I shall in this consider their *gravity* or *attraction*, which according to the modern philosophy (which hath great reason and probability on its side) hath a great agency in both these matters, both in effecting and preserving the figure of the globes, and governing their motion.

As to the agency of the natural attraction of matter, in the production and preservation of a sphaerical figure, as that of the several globes is, besides what hath been before supposed, it may be collected from the sphaerical figure which most fluids take, when there is

no obstacle to hinder their doing so. Thus I have said *quick-silver* manifestly doth, especially in small drops or quantities, in which case their own self-attracting power, is equal to, or exceeds that of the earth: so doth lead, and other metals, when in fluxion (a); so doth water, oyl, and in short all liquids, which run nearly into a sphaerical form, when hung on a small surface, as at the point of a pin; or into an hemispherical figure, on a broader surface; their self-attraction causing the former, as that of the earth, and the surface on which they lye, doth the latter. These Phenomena have indeed been ascribed to divers causes, most of them probable enough, except the pressure of the incumbent air; but this is manifestly not the true cause, by reason the case is the very same in the *air-pump* (when the pressure is taken off) as in the free air; and therefore some other cause

(a) This is very manifest from the making of shot. The way of doing which, is by running the melted lead through a ladle full of holes into cold water, in doing which they take care, their lead be not too hot, because the globules would then fly to pieces; nor too cold, because it would then be long and have tails; but in a due temper it turns round. They put orpiment into their lead, when they melt and prepare it for shot.

is to be found: and what more probable, or so probable, as this of *gravity* or *attraction*, which manifestly exerts itself in some, and is highly probable in all material things? (b) In the earth itself there is manifestly such a thing as *gravity*, which might as well be the natural cause of the sphaericity of our globe, as it is in that of lesser masses; but then, as I demonstrated in the last book, it is also evident, that an over-ruling power, and a wise providence, not only gave matter this gravitating power, but guided and managed it in the formation of the world.

And now upon supposition that *gravity* had any thing to do in the production of this sphaerical figure I am speaking of; the same it must have also in the conservation of that figure. For the same power it exerted at first, it retains still; which is as necessary still to the preventing and obviating all extravagant excursions, and deviations from that figure, which may happen through extraordinary commotions and convulsions in any of the

(b) For the proof of this I shall refer to Sir Isaac Newton's *Opticks*, Quest. 13. of the second edition, and in his *Principia* in many places, particularly Book 3. Prop. 5, 6, 7.

globes; such as earthquakes are, and other such like furious concussions and emotions that sometimes befall our own globe.

But leaving these conjectural matters, let us come to a more evident benefit of *gravity*, and that is the natural tendency of all bodies to the center of the globe: This is very manifest in our own globe. For whatsoever the decays are among earthly things, howsoever their forms are changed, yet their *matter* remaineth entire, and returneth again to its grand parent the earth: or to put in SOLOMON's words, Eccl. i. 4. "One generation passeth away, and another generation cometh: but the earth abideth for ever."

And an admirable provision this is for the perpetuity of the globe, and to continue the state and hability thereof throughout all ages, which would otherwise waste and decay, or run into the most irreparable and pernicious disorders.

C H A P. II.

The Guard which Gravity affords against the Centrifugal force of the several Globes.

UPON a supposition that every of the globes revolves round its own axis

(which I have sufficiently proved in the fourth book) we shall find, besides the benefits already specified, another very great use of gravity to the good, yea the very existence of our own and other globes, and that is the preservation of their integrity against the *centrifugal force* of this their revolution, or diurnal motion. For without such a band, as gravity, to keep their parts together, the whirling about of those globes would shatter them into pieces, and dissipate them abroad into the circumambient space. Thus must it needs befall our own globe, which whirls about at the rate of above 1000 miles an hour (a), and is composed of earth and water, materials of much too loose a texture, to prevent the dissipation, which the Centrifugal force of such a rotation must necessarily occasion, about the *Æquatorial* parts; a rotation that would as easily throw off the parts of the earth, especially the waters, as the whirling round of a wheel or a globe, would the loose dust and water lodged thereon. But by reason the Gravitating power exceeds the Centrifugal

(a) *The diameter of the earth being 7967.7 miles; according to B. I. Ch. 2. Note 1. the ambit thereof is 25031.4 miles, which being divided into 24 hours, makes the revolution to be at the rate of about 1043 miles an hour.*

as 2174 exceeds 7.54064 (b) that is above 288 times; therefore all parts lye quiet and secure in their respective places, and enjoy all the benefits, which I shewed do accompany this motion, without any disturbance from it. Thus is our own globe guarded by its Gravity against the Centrifugal force of its rotation. But this is far more remarkable in some of the other globes. Thus particularly in the Sun, whose ambit is, 2582873 miles, and whirls round once in about $25\frac{1}{4}$ days, and consequently doth revolve at the rate of 4262 miles, in an hour (c), which is above four times as fast as the earth; this in a little time would endanger its dissipation, without such a provision as Gravity is.

But what is this to the Centrifugal force of *Jupiter*? whose bulk far exceeds our ter-

(b) *This is the proportion or nearly so, of the gravitating, to the centrifugal force of the Earth under the Equator, as may be computed from Sir Isaac Newton's Princip. L. 3. Prop. 19.*

(c) *The Sun's diameter being 822148 miles, the numbers here assigned will naturally follow.*

As to the Sun's gravity or attractive power, it is (by the calculation of my friend the acute and learned Dr. Halley) to the Sun's Centrifugal Force, as 47000 to 1: The method for finding which, see in Note e.

aqueous ball, and whose rotation is performed in less than half the time. But from a computation of particulars, we shall better estimate the matter. The diameter of *Jupiter* being 120653 miles, its circumference is 379043 miles: which revolving round in less than ten hours, is at the rate of 38159 (d) miles an hour at its *Æquator*. And if the density of every planet be proportional to its distance from the Sun, as is now with great reason imagined, that is, if those planets nearest the Sun, as *Mercury* and *Venus*, are proportionably denser than those more remote, as *Jupiter* and *Saturn*; then is the globe of *Jupiter* of a laxer texture than ours is, and in so much the greater danger therefore of being whirl'd to pieces by so rapid a motion as that planet manifestly hath, were not its parts

(d) *Jupiter's ambit being 379043 miles, and his revolution 9 h 56 minutes or 596 minutes; the revolution in an hour is by the Logarithms thus.*

596 minutes	2.7752463
379043 miles	5.5786884
:: 60 minutes	1.7781513
	<hr/>
	7.3568397
	<hr/>
38159 miles	4.5815934

kept close together, and sedate, by such a band as *Gravity* (e) is.

CHAP. III.

Of the Power and Usefulness of Gravity to retain the Planets in their Orbits.

FOR a conclusion of this sixth Book, I shall take notice of one more remarkable benefit of *Gravity*, which is grounded upon the supposition of the truth of the *Newtonian Philosophy*; which hath so good grounds, and great reason, I might say demonstrations on

(e) *The proportion of Jupiter's, or any other Planet's, or the Sun's gravity, to their Centrifugal Force may be computed from the most sagacious Sir Isaac Newton's Princip. L. 3. Prop. 8. & 19. But the before commended Savilian Professor, suggested to me this easier and quicker rule, for such Planets as have Satellites, viz. The proportion of the Centrifugal to the Centripetal Force, or gravity of any planet at its surface, is compounded of the Ratio which the Cube of the Semidiameter of the Planet hath to the cube of the distance of any of its Satellites from the center of that Planet; and the Ratio which the square of the Satellites Periodick time hath to the squares of the Periodick time of the Planet's revolution. Thus for instance the distance of Jupiter's outermost Satellite being 253 Semidiameters of Jupiter, and its period 16 days, 16 hours, 32 minutes, or 24032 minutes, and Jupiter's revolution 526 minutes: we shall find the gravity in Jupiter's surface to be to his Centrifugal Force in his Equator, as 1 to 9. 96.*

its side, particularly in this matter, that admitting of it here, we shall discover another admirable work of the creation, and that is, the preventing the evagation of the Planets, and the accurate retaining them within the due bounds of their orbits. That this is done by *gravity*, and that *gravity* and *motion* solve in the most complete manner, all the Phaenomena of the planetary motions both primary and secondary, is abundantly made out by the wonderful sagacity of the great Sir Isaac Newton; as may be seen in his *Principia*.

But before I come to the particular agency of *gravity*, it will be necessary to premise something concerning its nature, and some of its properties, *viz.* That *gravity* is not terminated at the surface, but reaches to the very center, and is extended to immense distances all round the centers of all the globes: By which means, the celestial bodies are enabled to have systems of lesser globes revolving about them. For had the force of *gravity* determined at, or near the surface (as it might have done, if intended only for the conservation of the globes) in this case, all the bodies that were put in motion, and that were to pass at some distance from them, would move on

in a strait not curved line, and be lost in the great abyfs of space. But the all-wise CREATOR hath, in his first production of matter, bestowed upon it such a property, as that every particle thereof hath a tendency towards every other particle. From whence it comes to pass that every body hath a *Gravitating Power* according to the solid content, or real quantity of its matter, and not according to its superficies, or extension.

And this *gravity* of all bodies is observed, manifestly to decrease in proportion of the square of their distances reciprocally; that is, at twice their distance the force is but one fourth of what it was at a single distance; and but a ninth, at thrice the distance, &c.

That this is so, is abundantly proved by the last commended Author; who by establishing this one principle in Philosophy, hath fully explain'd the system of the world, so far as relates to us, and to all the rest of the Planets, that regard the Sun as a center, both primary and secondary.

What the cause of Gravity is, Sir Isaac Newton doth not pretend to assign, his design being not to engage himself in framing hypo-

theses, but to explain the Phaenomena by experiments only, and to raise his noble superstructure upon them. And therefore although the matters of fact, and the final causes are evident, I will not venture to say how it comes to pass, that bodies act at such immense distances upon one another; but chuse rather to acquiesce in adoring the wisdom and power of the GREAT AUTHOR of all things, who hath inspirited the materials of which the world consists, with such an active quality, as serves not only to preserve the globes themselves entire, but to enable them to revolve about their luminous center (from whence they have their light and heat) in orbs that are the most commodious, and also fixt and permanent.

Having thus premised what was necessary for the understanding the nature and properties of *gravity*, I shall proceed to consider its agency in the planetary motions. And here we have divers things, which plainly demonstrate these motions to be no matters of chance, but the works of an infinitely kind, as well as omnipotent and all-wise Agent.

I have already in Book 4. Chap. 2. taken notice, of the motion of the Planets, being made, not in lines tending from the center to

the circumference, or very obliquely thereto, but acrofs, or nearly perpendicular to the *Radii*. Also that the motions, and orbits of the Planets, do not tend contrary ways, or interfere with one another. That therefore which I shall speak of here, concerning the planetary motions being the work of God, will be only so far as gravity is therein concerned. And,

1. It was a very notable provision to prevent the evagation of the Planets, and to keep them within their due and proper bounds, to bridle and detain them with gravity, as with so many reins and bridles. For as the natural tendency of all imprest motion is in strait lines, so when motion was given to the Planets, this motion (altho' as I said it was artificially made, perpendicularly to the *Radii*, yet) would carry them quite away in their tangents, so that they would never return again. But being thus detained by gravity, another admirable provision is that, 2. They are moved in orbs: Which orbs are formed of a motion compounded of this rectilinear impulse, imprest upon the Planets, and the tendency of their gravity to the centers. In which motion a third thing very remarkable

is, That the impulse or velocity which is imparted by the first mover to every Planet, and the gravity of each Planet, are so nearly equal to what is required to make a body describe a circle, that the orbits of the Planets are not very eccentric, but nearly circular. As is particularly remarkable in *Venus*, and the earth; and more especially in the whole system of *Jupiter's satellites*. And an admirable work this is. For should the velocity of any Planet be double to what would make it move in a circle, the Planet would go away *in infinitum*, without ever returning again in any orb whatsoever. Or should one half of the velocity be taken away, the Planet would descend obliquely towards the Sun, until it became four times nearer the Sun than before; and then ascend again to its former place, describing a very eccentric orb. And by ascending and descending alternately, it would be heated sixteen times more at one time than another. Which uneven heat would make the Planet unfit for habitation. And the same thing would happen, if the determination of its motion should be altered, so as to become very oblique to the *Radius*, drawn from the Planet to the Sun. But these things being accurately adjusted and contempered, make the whole system to be a

work of incomparable convenience and beauty ; a work the best contrived for the benefit of the world's inhabitants, and to set forth the curiosity and skill of the infinite Workman.

It is manifest therefore that the system of the Planets is not to be reckon'd a matter of *chance* or a thing owing to a *necessity of nature*, but the work of a kind and wise agent. And that this is so, will be farther manifest from the case of Comets, whose motions, directions and orbs being utterly different from those of the Planets, demonstrate the Planetary system to have been modelled by counsel, and not by a necessity of nature, or left to chance. For as for the motion of Comets, it is so far from being always the same way, that they move sometimes contrary to one another. And as for their planes and directions, they lie every way. And as for their orbs, they are exceedingly eccentric. And by the bye, this eccentricity is an admirable contrivance of the CREATOR, to prevent the Comets from disturbing either the Planets, or one another, by their mutual attractions. For by this means, they have a large and sufficient room to revolve in ; and by ascending to very great heights, above the system of the Planets, and spending almost all their time in the re-

mote regions of the universe, at vast distances both from the Planets, and from one another, they do not incommode either the Planets, or themselves; as otherwise they would have done, should they have moved in the same plane with the Planets. For had they done so, they would have been apt sometimes to have come too near the Planets, and have disturbed their motions, and perhaps have dashed upon them also. But all these circumstances are so well adjusted, and so wisely regulated by the Divine Providence, that the system could not have been better contrived, either for convenience or beauty.

And now upon this highly probable, I might say physically certain theory, of gravity acting in the motion of the globes, we have another exquisite nicety, in the works of the creation, that justly deserves the greatest admiration and praise; that among so many immense, moving masses, they should all observe their due bounds, keep the most proper paths appointed for their convenience and good, and at all times answer the great ends to which they minister in the creation. Particularly that the habitable globes should always remain at such due distances, and move in such proper orbits, as are best for them.

And that the Comets too, should at the same time pass in paths utterly different, but yet such, in all probability, as may render them also of very great use to some or other parts of the world; whether we look upon them as places of torment (as hath been said) or bodies appointed for the refreshment and recruit of the Sun, or any of his Planets, as Sir Isaac Newton conjectureth in his *Princip.* L. 3. Prop. 41 & 42.

And now from the consideration of what I have shewn in this sixth Book, to be either highly probable, or very certain, concerning *gravity*, we have another manifest demonstration of the infinite CREATOR's wisdom and care, and another cogent argument to excite the highest veneration and praise in his creatures.

B O O K VII.

Of the Provision made for **LIGHT** and **HEAT**
throughout the **UNIVERSE**.

C H A P. I.

*Of the Light and Heat of the fixt Stars and
S U N.*

AS *light* and *heat* are two of the most useful things in the universe, so the infinitely wise and kind **CREATOR** hath made an excellent provision for these things; in all probability, for every globe throughout the universe, but particularly for those of our own system. For it is very manifest, that every globe we see, doth shine with its own native, or with borrowed light. Even all those immense bodies at the greatest distance from us, the fixt stars, which I have before said, are probably so many suns, it is light they manifestly dart as far as to our so distant globe, as well as what they emit for the enlightening, warming, and cherishing their own respective Planets.

But I shall forbear to launch out into those conjectural matters, and shall come nearer home, into our own system, where we have enough to entertain our eye, to captivate our thoughts, and to excite our highest admiration of these magnificent works of God ; whether we survey the great fountain it self of our light and heat, the Sun, its due position, and its wonderful use to its Planets ; and the incomparable provisions that are made to supply its absence and greater distances from them.

And in the first place, as to the Sun it self ; what power is there that the most extravagant fancy can imagine to it self, that could ever be able to make so prodigious a mass of fire as the Sun is, but only the power of God's Almighty hand ? A body of so immense a bulk, as I have shewn it is, and of such an excessive heat, that no greater a number of its rays, than what fall within the compass of a two or three inch burning glass, shall actually burn ; and what fall within the compass of not many feet, shall far exceed the strongest culinary fire in the earth : As is manifest from its almost instantaneous burning and vitrifying the most obdurate, incombustible bodies, such as not only green wood, and white bodies, but also stones, bricks, metals, yea gold it self (the

hardest of all metals to be wrought upon by fire) which yet is melted down in a few minutes (a)

Thus the infinite power and wisdom of GOD, appear in the appointment and make of that immense body of fire, the Sun; a mass wonderful, and worthy of its Maker, whether we consider its immensity, its excessive heat, or its absolute necessity, and great use to us, and to all the rest of its system. But we shall

(a) *The famous burning Concave at Lyons, of 30 inches Diameter, and others in France and Germany, of greater breadths, have been celebrated for their feats in burning, calcining and vitrifying, both metallic and other bodies. But I question whether any of them have come up to the Burning-Instrument contrived by and made for Sir Isaac Newton, and by him presented to the Royal Society. It consists of 7 concave foiled glasses, each of them 12 inches diameter, which are all so placed, as to have their Foci concur in one point. By which means the heat is so increased, as in a surprising manner, to perform the feats here mentioned, and many others surpassing them.*

Having mentioned these Burning Concaves, it may be of use on several occasions, and particularly for the cheap trying of experiments, to take notice of what was related to me by a Person of very high Quality: Who doing me the honour to talk with me about such Concaves, told me, that in Germany one Mr. Czbernhausen, a Silesian Gentleman, made divers very large Concaves with Paste-board; which were covered over with a kind of Paste or Foil, that strongly reflected the Sun's Rays. But what their power was, he did not see.

find yet farther evidences of the great CREATOR's work in the following chapter.

C H A P. II.

*Of the due Position and Distance of the Sun
and its Planets.*

AS the infinite power and wisdom of God appears in the appointment and make of the Sun, according to the preceeding chapter ; so in this I shall demonstrate the same, from the due position of the Sun among his Planets, and his due distance from each of them.

Now here we may take it for granted, that the Sun is the fountain of the light and heat of all the Planets, not only of the earth, but of the other Planets, that move either about the Sun, or the earth. But whether the Sun be placed in the center of its system, or the earth be so, is of no great consequence here to enquire. But I have all along supposed the former to be the most probable hypothesis, and it seems to be still more so, from the consideration we are now upon, concerning the

community of its light and heat to all the Planets. For since it is manifest, that what light and heat the Planets have, they receive from the Sun, it is far more likely that this their fountain of light, and heat, is placed in the common center of them, and that they move round about it rather than it about them.

But be it so, or not so, it is however very certain, that all the Planets are placed at such a due and proper distance, from the Sun, that they receive the beneficial rays thereof, in a due manner and proportion. There is no great reason to doubt of this, among the Planets that are at greater or lesser distances from the Sun than we, because we find a noble and solemn apparatus, answerable to their distances from the Sun; which I intend to speak of hereafter. But as for our own terraqueous globe, we have sufficient signals of the great care and counsel, that have been used in the due position, and distance thereof from the Sun. For as to its position to the Sun, I have heretofore shewn, that by the inclination of its axis, and its diurnal and periodical revolutions, all parts have a due share of light and heat. And as for its distance, it is such, as not only prevents the danger of its interfering with

the other globes, as I have formerly observed, but also it is duly adjusted to the density of the earth and waters, and to the make and temper of our bodies, and of all other things here below. Had we been much nearer the Sun, our world would have been burnt up, and wasted; the waters, in the first place, would have all been turned into vapours, and dried up; vegetation have soon ceased, and all things would have soon been wasted, if not burnt and consumed. Or had we been not at so very great a distance, but only a little nearer the Sun, than now we are, as suppose a few thousand of miles, still the heat would be as the square of the (a) distance; and consequently too great, if not for the Polar, yet for the *Æquatorial* parts. And on the contrary, had we been set at a greater distance from the Sun, so would the Sun's heat have been abated, in proportion to the square of that distance. And in this case if the distance had been very great, we and all things must have been perpetually frozen up; or if it had been not so great, the world would have suffered by cold, the Polar at least, if the *Æquatorial* parts could have escaped.

K 2

(a) *Newton. Princip. p. 466.*

And in this case, when our globe should thus be parched up with everlasting heat, or be everlastingly frozen with excessive cold ; instead of an habitable, pleasant, and comfortable world, it must become a desert, a place of irksomness, misery, and everlasting punishment. But the great CREATOR having so wisely, and indulgently, ordered the distance between the earth and Sun, the Sun's light and heat are incomparably accommodated to the state and temper of all things here below, and our world is well fitted for habitation, well provided with every thing that may minister to the support, the comfort and pleasure of its inhabitants. By those indulgent rays, all things are enlightened, and we, and all the rest of the animal kingdom, are enabled to dispatch our business, to seek and provide our food, and to pass from place to place, as our occasion or pleasure lead us. By its cherishing beams all things are warmed and comforted, vapours, in some measure, made to rise for the forming of clouds and rain ; trees and plants are enabled thereby to put on their verdure and gaiety, and to yield us the benefit and pleasure of their grain and fruit. By the presence of this great fountain of light and heat, we and even nature too, is awake

and excited ; and by its absence, grows torpid and dull : Its absence by night, disposes us to rest and sleep ; and even vegetables too shut up their flowers then (b), and in a manner betake themselves to rest : And its absence in winter, how doth it change the whole face of nature, divest vegetables of their gay attire, force animals to places of shelter and safeguard, and give an aspect of melancholy and horror to all things !

Thus it is manifest how wisely and indulgently the great CREATOR hath provided for the good of our planet, by so critically adjusting its position to, and its distance from the Sun, to the state and temper of it, and all things thereon. And although the rest of the planets encompassing the Sun, are some of them near to, some of them farther from it, yet there is no great question to be made, but the same wise Contriver hath made as good a provision for them as for us, either by tempering their density to their distance from the Sun, or by some other the wisest and best course ; as we have very just reason to suspect, from that grand and solemn apparatus

K 3

(b) See *Physico-Theol.* Book 10. N. 14.

I shall speak of, of secondary planets. Which leads me to consider the provisions made for the supply of the Sun's absence, and its greater distance.

C H A P. III.

The Necessity of Light, and the provision for it by the Atmosphere.

BEFORE I come to the other planets, it will be convenient to consider how the Sun's absence is supplied here upon the earth, as also, probably, how it is supplied in her concomitant the Moon.

And first as to the earth. Of such absolute necessity is light, (not to mention heat) that our world could not well be in the least utterly without it, because if there should be utter, absolute darkness (besides the great inconveniencies it might bring to vegetables, minerals, and every other such like part of the creation, besides this I say) it would certainly put animals under an absolute incapacity of performing their most necessary business, and acting in that office which the Divine Providence hath appointed them, although of

greatest use to themselves, or the rest of the world. Men, for instance, whose business and occasions oftentimes necessitate them to borrow a part of the night; and all other animals, particularly such whose safety, or temper, or constitution of parts (as of their eye, for instance, or some other parts) confine them to their dens, and places of retirement and rest by day, and are therefore in course compelled to seek their food, and wander about on their most necessary occasions of life by night; all these, I say, would at once be cut off from one of the grand benefits of life, from acting that part they bear in the creation, during such time as they should be put into absolute darkness. But to prevent this, the infinitely wise Contriver of the world hath made divers admirable provisions, both in our own, and the other planets too. One provision which he hath made in our own globe, and I might add that of the Moon also, is by encompassing both with an atmosphere (a),

(a) *Mr. Huygens in his Cosmotheor. p. 115 concludes the Moon to have no air or atmosphere, because we see its limb so clearly and accurately defined, and because he thought there are no seas or rivers in the Moon. But he was mistaken both in his conclusion and part of his premises. For in the Solar Eclipse May 1. 1706, which in Switzerland was total, they could manifestly perceive*

which among other grand uses, ministers very much to the propagation of light, partly by reflecting the rays of light to our eyes, and partly by refracting them, so as to make them visible and useful to us, when otherwise they would not appear. Hence that whiteness and brightness (b) observable in the air by day; and hence the twi-light, when the Sun is hidden under the horizon. The like to which is observable in the Moon also, in that secondary, rusty light which is seen in her eclipses, and before and after her quarters.

the Moon's atmosphere, at may be seen in the accounts given in Philos. Transf. No. 306. And since that, in the last total Eclipse of the Sun, April 22. 1715. the Moon's atmosphere was very discernible, appearing in the form of a curious ring of vapours encompassing the Moon all the time of total darkness. Of which see the accounts, in the Philos. Transf. and Mr. Whiston's.

(b) See *Physico-Theol*, B. I. C. I. Note 12.

C H A P. IV.

The great Usefulness of the Moon, and the mutual beneficial Returns which the Globes make to one another.

HAVING shewn the absolute necessity of light, and the supply thereof by atmospheres; let us next speak of the principal provision made for that, and for supplying the Sun's absence, and that is by the *Moon* and *Stars*, which as Moses saith (a) *rule the night, as the greater light, the Sun, doth rule the day.* What influences these celestial bodies may have here below, in the bodies of men, and other animals, or among vegetables, fossils, or in any of the grand works of Nature, is hard to determine, although vainly pretended unto by the judicial Astrologers: but yet some things there are, whose periods and crises so strictly observe the courses of the Sun, especially of the Moon, that on the other hand, it is hard to deny the influences of these bodies here below. The tides particularly have all along so constantly observed the

(a) *Gen. i. 16.*

courses of the Moon, that in all ages they have been suspected to be caused and governed by that planet: and if the stories of Pliny (b), Aristotle, and others of the ancients be true, it is by her influence, that the bodies of oysters and other shell-fish are increased and diminished; that the mass of man's blood is so also; that the humours are resolved and attracted, that the dead bodies of beasts are corrupted; that all animals expire at the time of ebb, particularly man; that the sea purgeth it self of filth every full-moon, which gave occasion to the fable of the Sun's having his stable about *Messina* and *Milazzo*; and divers other such like conceits, which those authors name, too many, and too improbable, to deserve to be reckoned up in this place.

But whatever influences the Moon may have upon things here below, whatever her concern may be in any transaction of nature, or any other office of the creation, it is however very certain that her *Light*, *Eclipses*, *Monthly Revolutions*, and *Latitude*, or vagations towards our poles; are of great use to us.

By her *light*, to which I may add that of the *stars*, we and the rest of the creatures are

(b) *Plin. Nat. Hist. l. 2. c. 41, 98, 99, 101.*

able to protract our day at pleasure, to go hither and thither, as our occasions call, and to dispatch many of our affairs by night, or to betake ourselves to repose and rest, to which, according to Pliny (c), the Moon doth naturally incline us.

As to the *Eclipses*, whether of *Sun* or *Moon*, they have their excellent uses too. The astronomer applies them to considerable services in his way; and the geographer makes them no less useful in his; the chronologer is enabled by them to amend his counts of time, even of the most ancient days, and so down through all ages; and the mariner too can make them serviceable to his purpose, to discover his longitude, to correct his account at sea, and thereby make himself more secure and safe in the untrodden paths of the deep.

So for the *Monthly Revolutions* of the Moon, besides the uses they have in the daily variations of the tides, and perhaps causing some such revolutions too in the humours and bodies of animals, and in the works of nature; besides this I say, they are manifestly of ex-

(c) Ferunt Lunae foemineum ac molle Sidus, atque nocturnum, solvere humorem, et trahere, non auferre. Id manifestum esse quod—Somno sopitis torporem contractum in caput revocet. Plin. L. 2. cap. 101.

cellent use in the divisions of time, in measuring out our months, as the Sun doth our days and years, according to that appointment of the Creator. Gen. i. 14. “ And
“ God said, let there be lights in the firmament of the heaven, to divide the day from
“ the night; and let them be for signs, and
“ for seasons, and for days and for years.”

And lastly as to the *Lunar Latitude*, or progresses towards our poles, besides the use hereof to the preventing the too frequent Eclipses of the Sun and Moon, those vagations are of great use to the polar parts of the world, in affording them a longer, as also a stronger and better light, than if the rays fell more oblique: which must needs be a very great comfort, and of wonderful service to the inhabitants of those forlorn parts, in their long and tedious nights, of some days, yea some months lengths: to men, to enable them to dispatch such of their affairs as are of perpetual and constant necessity; and to other animals of the air, land, or waters, to enable them, with greater ease and pleasure, to get their food, and pass where their pleasure leads them.

Thus the great CREATOR hath made the Moon to be of admirable use to our earth. And so wisely hath he contrived his works, that

they are mutually serviceable to one another, so that what good services one doth, the other as readily returneth again. Thus as the Moon is a Moon to us, so the earth is with great reason concluded by the philosophers, to be a Moon to the Moon; not indeed a secondary planet moving periodically about her, but such a planet, as reflects the light of the Sun to her, and perhaps makes such like returns of influx, as I said the earth receives from her. For it is not to be doubted, if the earth reflects light, and gravitates to the Moon, as well as the Moon to the earth (which is highly probable) but that there is a mutual intercourse, and return of their influences and good offices. And this is still more probable from the likeness discernible between the earth and the Moon, which is a strong presumption that the Moon may have the same occasions for the earth, as the earth for her. For that she is an opaque body, and that her surface is covered in some measure with hills and valleys, is manifest beyond all doubt to our eye (d) as I said before: And that she hath an atmosphere, is

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(d) See Book 5. Chap. 2. Note c]

what hath been not long since (e) discovered : And that there are large oceans and collections of water is what I have before made probable (f). And therefore agreeing thus in constitution and make, their occasions for, and influences upon each other are in all probability mutual, and much the same.

And after this manner the infinitely wise *Contriver* of the universe seems to have transacted throughout that immense space, by making all the several globes useful to one another. Thus all the Planets of our solar system are of considerable use to us, all of them reflect light unto us, and some of them a light so bright and strong (as particularly *Venus* and *Jupiter*) that they are a good supply of the Moon's absence in the night, as well as the Sun's. Nay the very *secondaries* (which I shall shew are of greater use to their primary Planets) have their uses too amongst us; not only as being evident demonstrations of the great works of God, but also in ministering to the discovery of the longitude of the most distant places upon the earth. So for the *fixt stars*, which I have before shewn to be (probably) so many Suns, ministering to as many

(e) See before, Chap. 3. Note a.

(f) Book 5. Ch. 4. Note a, as also the Preface.

systems of the Planets; it is certain they are of great use to us in supplying the absence of the Sun and Moon by night. And there is no great doubt to be made, but that the like returns are made to them, and their systems by our Sun. So that here we have an admirable oeconomy observable throughout all the visible regions of the universe, in the mutual assistances, and returns, which one globe affords the other, even at the greatest distance.

C H A P V.

Of the Moons, or secondary Planets in general, which are observed about some of the primary Planets.

HAVING taken a view of the methods which are used for the accommodating the earth with light and heat, let us cast our eye to the rest of our *Solar system*, and examine whether any thing of the like kind is to be found there. And here we shall find a no less admirable scene of the great CREATOR's care and wisdom, than we discovered in the earth and Moon. In *Mars* indeed, we

can discern a great similitude with the earth, in its opacity and spots, but we have not yet been able to perceive any attendance of Moons, as in the other superior Planets; not so much probably because there are none, but because they are small, or they reflect a weak light and are at a great distance from us, and as for *Venus* and *Mercury*, there may be no occasion for any attendants, by reason of their proximity to the Sun. But in the two highest, or more distant Planets, *Jupiter* and *Saturn*, we have a very noble, and entertaining scene of the CREATOR's glory. For whereas those two Planets are at a much greater distance, than any of the other Planets, from their fountain of light and heat, the Sun; and as consequently their heat and light are abated in proportion to the square of their distances; so to make them amends, they are surrounded with a more grand retinue, of *secondary Planets*, or Moons; *Jupiter* with four, *Saturn* with five, as it is imagined, and probably more (a).

(a) *Mr. Huygens in his Cosmotheor. p. 99. gives this account of the discovery of the Satellites of Jupiter and Saturn, That it is well known the discovery of the Circumjovials is owing to Galilaeo; that the brightest, and the uttermost Circumsaturnial he happened to see with a 12 foot glass in the year 1665; that the*

And an admirable remedy this is, not only for the great distance of these two Planets from the Sun, but also for the tardity of the periodick motion in their respective orbits. For whereas *Saturn* revolves round the Sun but once in near thirty years, and *Jupiter* but once in near twelve, it comes to pass that the places near the two poles of those Planets, have a night of near fifteen years in *Saturn*, and six in *Jupiter*, supposing their axes inclined to the planes of their orbits, as it is in our own globe. But supposing (as it is imagined) that their axes are not so much inclined, and that their days and nights, their winters and summers, are nearly equal; in this respect, the case would be worse than in the long nights, in the other case: but in both

rest are owing to Cassini, who first saw them with a glass of Campani's grinding, of 36 feet, and afterwards with one of as many feet above an hundred. *That* the third and fifth, Cassini shewed him in 1672. and afterwards oftner. That Cassini acquainted him, by letter afterwards, with his discovery of the first and second in 1684. That the two last are not easily discerned, and he cannot say he ever saw them. That besides these five, he suspects there may be one or more lye concealed. Of which see Chap. 7. following.

cases. the polar parts of both those Planets, would be dismal regions of darkness, when so long detained from the kindly visits of the Sun. But an admirable remedy is found, and a glorious scene of the great CREATOR's works appears therein, as will be manifest by considering particulars in each of those two superior Planets.

C H A P. VI.

Of Jupiter's Moons, Days, and Seasons.

IN speaking concerning the superior Planets in particular, I shall begin with *Jupiter*. The distance of this Planet from the Sun, is reckoned to be 343 millions of miles farther from the Sun than we are; and by that means, the Sun's light and heat are 27 times less there than with us, and its apparent diameter, five times less (b). And considering how vast a globe *Jupiter* is, having its superficies 100 times, yea, (according to Mr. Huygens' computations) 400 times bigger than that of the

(b) *Gregorii Astron. L. 6. Prop. 5. Mr. Huygens makes the light and heat but 25 times less, and the apparent diameter 5 times. Cosmoth. p. 103.*

earth; in this case, what a vast tract of that globe must needs lie in profound darkness, and desolation, had no remedy been provided! But there are divers provided. One is by the frequent rotations of *Jupiter* round his own axis; which being performed in less than 10 hours, it comes to pass, that what is wanting in the strength, and degree of light and heat, is compensated by the frequent returns thereof.

The other remedy is by the increase of the number of *Moons* about *Jupiter*, who is attended (as I said) with four, as we who are nearer the Sun, are with one. Concerning which these four things are remarkable.

1. Their bulk, which in all probability, is not in any of them less than our earth, as the most ingenious Mr. Huygens concludes (c) from their shade upon *Jupiter's* disk. By which partly it is that,

2. They reflect so strong, brisk, and vivid a light, as appears very illustrious, and entertaining, even to us at so great a distance from it: Which cannot but be very pleasing and comfortable to that Planet: Besides the no less beneficial and friendly influences conveyed therewith at the same time.

(c) *Cosmotheor.* p. 101.

3. Their due distances from *Jupiter*, and from one another; and their agreeable periodick revolutions, which I have formerly observed (d) to be in the most exact mathematical proportions. By the first of these, those Satellites escape all disagreeable concourses, and violent oppositions, and, in the most kindly manner, send their influx to the Planet they wait upon: And by the latter, they are perpetually carrying about their light, and other benefits from place to place. For by the motion of the innermost, round once in less than two days; of the next in about $3\frac{1}{2}$ days; of the third in somewhat above a week; and of the outermost in near 17 days: By these means, I say, it happens very seldom that any part of *Jupiter* is at any time without the presence and attendance of one or more of those satellites; but one is visiting one part, whilst another is attending another, and another another part, and *Jupiter* himself making speedy returns and revolutions all the while.

4. The last thing remarkable is the latitudes of *Jupiter's* Moons, or their progresses towards his poles, which are in a due proportion to their distances and periods: as I have before shewn, B. 4. C. 5.

(d) *Book 4. Chap. 4.*

And as the latitudes of these satellites differ, according to their distances and periods; so another remarkable thing therein, is, that they shift their latitudes in longer or shorter times, according as their latitudes, or vagations towards the polar parts of *Jupiter*, are greater or lesser. By which means, some are making their progresses towards *Jupiter's* poles one way, whilst some are wandering the other way, and some are staying there a longer time, and some a lesser and lesser time. By which quadruple variety of latitudes, and perpetual changes of it, it comes to pass, that those large tracts towards the polar parts of that vast planet, have their due share in the light, and kindly services, of its four Moons, and are seldom or never deprived of them.

C H A P. VII.

Of Saturn's Moons, Ring, Days, and Seasons.

HAVING seen the admirable provision made for the remedying *Jupiter's* great distance from the Sun; let us, in the last place, take a view of *Saturn*; which is above 200 millions

of *English* miles farther from the Sun than *Jupiter*, and near 700 millions of miles farther than is our earth. And here our glasses, as imperfect as they are, have discovered so surprizing an apparatus, that must needs strike every one that views it with wonder and amazement.

For, in the first place, instead of four satellites or moons, as *Jupiter* hath, *Saturn* hath five, and probably more. Three of these I my self have seen with Mr. Huygens 120 foot glass; but for want of a pole of sufficient height to mount the glass high enough, I am not sure I have seen any more. And besides those five, which others have seen; there is great reason to conclude there is a sixth lying between the two outermost, there being a larger space between them, than is in proportion to what is found amongst the rest. And it is not improbable but that there are others also lying beyond the fifth, or the outermost, but become invisible at so great a distance from us, by means of some obscurity, such as is observable in the outermost itself, which is never to be seen by us, but in the western part of its orbit, as Mr. Huygens well observes (a).

(a) *The reason why Saturn's fifth satellite appears not on the eastern, but western part of its orbit, Mr.*

These satellites we may reasonably conclude to be of a prodigious bulk, for the reflecting of light, and for their other ministrations to *Saturn*, because otherwise they could not be seen at so great a distance as the earth; and particularly one of them (b) is of that magnitude, and its light so brisk and vivid, that it appears very illustrious through our longer glasses, and may be discerned with our shorter.

As to the *distances*, the *periods*, and *latitudes* of those satellites, they being consentaneous to what I have already taken notice of in *Jupiter*, I shall not insist upon them, but pass to another provision made for the great distance of that Planet; which is a thing so singular to *Saturn*, so unusual in all the

Huygens very sagaciously, like himself, conjectures to be, because this satellite, as the Moon doth to the earth, always turns one and the same side to *Saturn*, and because this satellite hath, he imagines, only one part of its surface clear, and the greatest part obscure, and not able to reflect sufficient light to us; therefore all the time that obscure part is turned towards us (which is whilst the satellite is in the Eastern parts of its orbit) it disappears: but in the Western parts it appears, because the bright sides lie towards us. *Cosmoth.* p. 118.

(b) It is the fourth satellite, or outermost but one, called from its first discoverer, the *Huygenian Satellite*, that is so visible.

rest of the creation, and so amazing, that it is an evident and noble demonstration of the great CREATOR's *art* and *care*; and that is *Saturn's ring*. Concerning which these things are observable.

1. The prodigious *size* of it, its great breadth and vast compass, this we may make a judgment of, by comparing it with *Saturn* himself. And supposing the diameter of *Saturn* to be, as is before determined, 93451 *English* miles, the diameter of his ring will be 210265 such miles, and its breadth about 29200 (c); an amazing arch to an eye placed in that Planet.

2. The due and convenient distance of it from *Saturn* it self; not closely adhering to it, because that would annoy a large portion of *Saturn's* globe, by depriving it of the Sun's rays, but environing it about the distance of its breadth; by which means the Sun's light and heat are permitted to enter between the Planet and its ring, whilst other rays are, at

(c) *Mr. Huygens in his Systema Saturn. p. 47. and Cosmotheor. p. 109. determines the diameter of Saturn's ring to the diameter of Saturn, to be as 9 to 4; and the breadth of the ring, and distance of the ring from Saturn's body, to be nearly equal, and accordingly these numbers are defined here.*

the same time, reflected upon the planet by the ring.

3. The thickness of the ring, which is hardly, if at all perceivable by us; which is as great a benefit, as its edging shade would be an annoyance, was the ring thick.

4. Its smoothness and aptitude to reflect light and heat (d) is a wonderful convenience in it. Was it full of mountains and vallies, and I may add waters too, as in our earth, and probably the Moon likewise, the reflections would be too weak to render the *ring* visible unto us, at so great a distance as we are; but perceiving its light to be so lively and strong, as to render both itself, and *Saturn* very illustrious, it is a demonstration of the aptitude of its structure, and smoothness for the reflection of light and heat to the Planet it serves.

5. As the periodical revolutions of the earth are an excellent and providential contrivance, for those useful and necessary mutations we have of the seasons of the year, so no doubt but the same benefits accrue to those revolutions, which *Saturn* hath about the Sun. It is visible that as *Saturn* changes its place in its

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(d) See *Huygen. Syst. Saturn. p. 70.*

orbit, so its *ring* receives a variety of aspects (e) not only with respect to us, but to the Sun. Thus in one part of the orbit it appears with a (f) larger ellipsis, so as to exhibit a large space between it and *Saturn*: in another part, with a lesser, and so with a lesser ellipsis, and sometimes as only a slender strait line, and sometimes it is not visible at all (g);

(e) Every 14 or 15 years *Saturn's ring* hath the same face; appearing at one time with large open ansae, at another time with no ring at all. Which appearances is obtained by gentle progresses from the one to the other face. As, if the ansae are the largest, they gradually diminish, until no ansae or apertures are to be seen in the ring, and at last no ring at all also. See Fig. 8.

(f) This Mr. Huygens shews, is when *Saturn* is 20 and one half degrees in Gemini and Sagittary. This was the appearance it had in April 1708, and which it will again receive at the end of 1722; only with this difference, that whereas the ring traversed the upper or northerly part of *Saturn's disk* in 1708, it doth now, and will for some years to come, traverse the lower or southerly part thereof, as is represented in Fig. 7.

(g) Mr. Huygens shews that for about six months before and after *Saturn's* being in 20 and a half degrees of Virgo and Pisces, the ring is not visible, but *Saturn* appears round. Syst. Saturn. p. 59, 74, &c. And accordingly at this very time, there is no appearance of the ring, only a small narrow list or belt crosseth the middle of *Saturn's disk*, of a colour somewhat different from the rest of *Saturn's phase*, and in the place

also sometimes one side of the ring is enlightened, and reflects light towards one part of *Saturn*, sometimes the other enlightens another part; and there is no doubt, but that as our earth has its seasons, according to its position to the Sun, in its periodical motion in its orbit; so *Saturn* throughout his period, hath his seasons, according unto his position to the Sun, and the various reflections of the ring upon the several parts of his globe (h).

These five things observable in *Saturn's* ring, we have pretty good assurance of, from

where the ring should be. This appearance of Saturn is represented in Fig. 8. which is the appearance he had through a very good 34 foot glass, at the latter end of Octob. and beginning of Nov. this present year 1714. But a little before this, viz. on Sept. 26. I could through an 126 foot glass discern the narrow ends of the ring on each side Saturn. A representation of which I have given in Fig. 9.

(h) *There is very great reason to imagine this doth certainly happen in Saturn, because, as Mr. Huygens observes, Saturn appears sometimes more splendid than at other times. Ita semper, saith he, quo propius versus Cancrī et Capricornī signa accesserit, eo majorem aut certe splendidiorē, etiam absque telescopio appariturum, quippe Annuli Ellipsi semper se latius pandente. Huygen. Syst. Saturn. p. 56.*

our views through good glasses. But there is a

6. Thing I shall add as only conjectural, and that is a supposition that the axis of *Saturn* (i) is inclined (and that pretty much also) to the Plane of its ring or the Plane of its orbit at least; and that he hath a diurnal rotation in some certain short space of time. For without these two conveniences, very large tracts of *Saturn* would suffer extremely for want of the Sun. For if *Saturn* hath no other motion, but that round the Sun in its orb, one part must be excluded from the Sun's visits for 15 years whilst the other partakes all the while of them; and one hemisphere will enjoy the benefit of the ring, whilst the other is eclipsed by it: and in this case the ring would be nearly as prejudicial to the eclipsed part, as it is useful to the enlightened. But supposing *Saturn* to move round in the same, or a shorter time than *Jupiter*, and in a path pretty much inclined to the ring, all parts then of that vast Planet will have their frequent returns of day and night, of heat and cold. And since this is what is discernible in the other Planets, and is no less necessary for

(i) *Mr. Huygens determines the inclination of Saturn's axis to the plane of his orbit to be 31 gr. as that of the earth is 23 degrees. Cosmotheor. p. 108.*

the benefit and comfort of this we may reasonably conclude the thing to be probable, although not discernible at *Saturn's* great distance from us.

C H A P. VIII.

The CONCLUSION.

THUS I have taken a view of the provision made for those two grand, and universal necessities, light and heat; things, in all probability, no less necessary for the other globes, than for our own; and things which not only animals cannot subsist without, but what all things here below, stand in need of, as well as they. When therefore we actually see, and feel those indulgent provisions, those amazing acts of the great CREATOR; when we have views of their extent into myriads of other the most distant globes; when (to go no farther) we see in our own system of the Sun such a prodigious mass of fire as the Sun is, placed in the center, to scatter away the darkness, and to warm and cherish us by day, and such a noble retinue of Moons

and stars, attending and assisting us by night; when we see this *indulgence*, this *care* of the CREATOR, extended to all the other Planets, and that according to their several distances, they have a proportionate provision of the greater number of Moons, and *Saturn* a stupendious *ring* besides, to supply the decrease of light and heat; who can be otherwise than amazed at such providential, such useful, such well contrived, such stately *works* of GOD! Who can view their glories and partake of their beneficial influences, and at the same time not adore the *wisdom*, and praise the *kindness* of their CONTRIVER and MAKER! But above all, should there be any found, among rational beings, so stupid, so vile, so infatuated with their vices, as to deny these *works* to be GOD's, and ascribe them to a *necessity of nature*, or indeed a mere *nothing*, namely *chance*! But such there are to be met with among ourselves, and some such the prophet tells us of, *Isai. v. 11, 12.* Men that had so debauched themselves with drink, and enervated their minds by pleasures, that “they regarded not the work of the
“ Lord, neither considered the operation of
“ his hands.” Such persons have led their

lives in such a manner, as to wish there was no GOD to call them to account, would then persuade themselves there is none; and therefore stupidly ascribe those manifest demonstrations of the infinite *power* and *wisdom* of GOD, to a mere nothing rather than to their great Author. But may we not with as good reason imagine a lighted candle, a well-made culinary fire, a flaming beacon, or light-house, to be the work of *chance*, and not of *man*, as those glories of the heavens not to be the *works of GOD*? For it is very certain, that as much wisdom, art, and power worthy of God, is shewn in the lights of the heavens; as there is in those upon earth, worthy of man, which none can doubt were contrived and made by man. And if from these mean contrivances and works of man, we conclude them to be the works of man; why not the grand, the amazing works of the heavens, surpassing all the wit and power of man, why not these, I say, the works of some being as much superior to man? According to the argument of Chrysippus which shall conclude this book. “ If there be any being that
“ can effect those things, which man, al-
“ though endowed with reason, is not able

“ to effect; that being is certainly greater,
“ and stronger, and wiser than man. But
“ man is not able to make the Heavens;
“ therefore the being that did make them,
“ excels man in art, counsel, prudence and
“ power.”



B O O K VIII.

Practical Inferences from the foregoing S U R V E Y.

IN the foregoing seven books having taken a view of what presents it self to us in the *Heavens*, and seen a scene of the greatest grandeur, a work well contrived, admirably adapted, and every way full of magnificence; all that now remains is, to endeavour to make these views and considerations useful to ourselves, Which I shall do in the following chapters.

C H A P. I.

The Existence of GOD collected by the Heathens from the Works of the Heavens.

THE first and most ready and natural deduction we can make from such a glorious scene of workmanship, as is before represented, is to consider, *who the great Workman was?*

That the author of all this glorious scene of things was GOD, is such a conclusion, that even the most ignorant, and barbarous part of mankind have been able to make from the manifest signals visible therein; signals so plain and conclusive, that Tully's *stoick* (a) cites it as Aristotle's opinion, “ That if there
 “ were such a sort of people, that had always
 “ lived under the earth, in good and splen-
 “ did habitations, adorned with imagery and
 “ pictures, and furnished with all things that
 “ those accounted happy abound with: and
 “ supposing that these people had never at a-
 “ ny time gone out upon the earth, but only
 “ by report had heard there was such a thing
 “ as a Deity, and a power of the Gods; and
 “ that at a certain time afterwards, the earth
 “ should open, and this people get out of their
 “ hidden mansions into the places we inhabit:
 “ When on the sudden they should see the
 “ earth, the seas, and the heavens, perceive
 “ the magnitude of the clouds, and the force
 “ of the winds; behold the Sun, and its gran-
 “ deur and beauty; and know its power in mak-
 “ ing the day, by diffusing his light throughout

(a) *De Nat. Deor. L. 2. c. 37.*

“ the whole heavens; and when the night
“ had overspread the earth with darkness, they
“ should discern the whole heavens bespread
“ and adorned with stars, and see the variety
“ of the Moon’s phases in her increase and
“ decrease, together with the risings, and
“ settings, and the stated and immutable courses
“ of all these throughout all eternity; this
“ people, when they should see all these
“ things, would infallibly imagine that there
“ are Gods, and that those grand works were
“ the works of the Gods.” Thus have we
the opinion and conclusion of two eminent
heathens together, Aristotle and Tully’s *snick*.

And if the *Heavens* so plainly “ declare
“ the glory of God, and the firmament shew-
“ eth his handy work (b);” if those characters,
those impresses of the divine hand, are so
legible, “ that their line is gone out through
“ all the earth; and their words to the end
“ of the world, so that there is no language,
“ tongue, or speech where their voice is not
“ heard;” nay if these things are such, that
even a subterraneous people would, at first
sight, conclude them to be GOD’s *work*; how
daring and impudent, how unworthy of a

(b) *Psalms* xix. 1. &c.

rational being is it, to deny these works to GOD, and ascribe them to any thing, yea a mere *nothing*, as *chance* is, rather than GOD? Tully's *stoick* last mentioned denieth him to be a man who should do this. His words (c) are, “ Who would say he is a man, who when
 “ he should behold the motion of the heavens
 “ to be so certain, and the orders of the stars
 “ so established, and all things so well connected and adapted together, and deny that
 “ reason was here, and say these things were
 “ made by chance, which are managed with
 “ such profound counsel, that with all our wit
 “ we are not able to fathom them? What! *saith he*, “ when we see a thing moved by
 “ some certain device, as a sphere, the hours,
 “ and many things besides; we make no doubt
 “ but that these are the works of reason. And
 “ so when we see the noble train of the heavens, moved and wheeled about, with an
 “ admirable pace, and in the most constant
 “ manner, making those anniversary changes,
 “ so necessary to the good and preservation of
 “ all things; do we doubt whether these things
 “ are done by reason, yea by some more excellent and divine reason? For, *saith he*,

(c) *Cicero ibid. cap. 38.*

“ setting aside the subtilties of disputation,
“ we may actually behold with our eyes, in
“ some measure, the beauty of those things
“ which we assert are ordered by the Divine
“ providence.” And then he enters into a
long detail of particulars of this kind, too
many to be named here.

Thus Cicero, throughout whose work so
many passages of this nature occur, that it
would be endless to cite them: And there-
fore one observation that shews what his o-
pinion was of the sense of mankind in the mat-
ter, shall close what he saith, and that is in his
book *de legibus* (d), where he saith, “ Among
“ all the tribes of animals, none but man
“ hath any sense of a God; and among man-
“ kind there is no nation so savage and bar-
“ barous, which altho’ ignorant of what God
“ it ought to have, yet well knows it ought
“ to have one.”

And after the same manner Seneca (e),
who instanceth in two things to shew the de-
ference we are apt to give to the general pre-
sumption and consent of mankind. One is

N

(d) *L. i. c. 8.*

(e) *Epist. 117,*

in the *immortality of the soul*; the other is in the “Existence of a Deity; which, *saith he*, among other arguments we collect from the innate opinion which all men have of the Gods: For there is no nation in the world so void of law and morality, as not to believe but there are some Gods.” Nay, so positive he is in this matter, that in another place he expressly saith, “They lye that say, they believe there is no God. For although by day they may affirm so to thee, yet by night they are to *themselves* conscious of the contrary.” Much more could I cite out of this famous heathen; but one passage, relating to the Heavens, shall suffice, and that is in his discourse shewing “why evils befall good men, seeing there is a Divine providence (e).” He takes it for granted in this discourse, „ that there is such a thing as a **DIVINE POWER** and **PROVIDENCE** “governing the world; *and he saith*, it was needless for him to shew that so great a work (*as the world*) could not stand without some ruler; that so regular motions of the stars could not be the effects of a fortuitous force, and that the impulses of chance must be oftentimes disturbed and justle: That this undis-

(e) *Quare bonis viris, &c. c. i.*

turbed velocity, which bears the weight of so many things, in the earth and seas; so great a number of heavenly lights, both very illustrious, and also shining by a manifest disposal, must needs proceed by the direction of some eternal law: That this can never be the order of straggling matter; neither is it possible for things fortuitously and rashly combined, to depend upon, and manifest so much art." Divers of which matters he proceeds to instance in. Thus Cicero and Seneca: To whose evidences I might have added many others, particularly a great deal out of Plato (the *Divine* Plato, the *Homer of philosophers*, as he is called by the antients:) but it would be needless, as well as tedious, since these two former have given us the sense of mankind, as well as their own opinion in the matter.

C H A P. II.

GOD's Perfections demonstrated by his Works.

AS GOD's *works* have been shewn to be manifest demonstrations of his *existence*; so they are no less of his *perfections*, particular-

ly of his infinite *power*, *wisdom*, and *goodness*; inasmuch as every workman is known by his work. A palace that should have nothing defective in situation, beauty, or convenience, would argue the architect to have been a man of sagacity, and skilful in Geometry, Arithmetic, Optics, and all other mathematical sciences, serving to make a man a complete architect; yea to have some judgment in Physic, and Natural philosophy too. And so this glorious scene of GOD's works, the Heavens, plainly demonstrate the Workman's infinite *Wisdom* to contrive, his *Omnipotency* to make, and his infinite *Goodness*, in being so indulgent to all the creatures, as to contrive and order all his works for their good. For what less than *infinite* could effect all those grand things, which I have in this discourse shewn to be manifest in the Heavens? What architect could build such vast masses, and such an innumerable company of them too, as I have shewn the Heavens do contain? What *Mathematician* could so exactly adjust their distances? What *Mechanic* so nicely adapt their motions, so well contrive their figures, as in the very best manner may serve to their own conservation and benefit, and the convenience of the other

globes also? What *naturalist*, what *philosopher*, could impregnate every globe, with a thing of that absolute necessity to its conservation, as that of gravity is? What *optician*, what *chymist* could ever have hit upon such a noble apparatus for light and heat, as the Sun, the Moon, and the stars are? could amass together such a pile of fire as the Sun is? could appoint such lights as the Moon and other secondaries are? None certainly could do these things but GOD.

C H A P. III.

Of GOD's Relation to us, and the Duties resulting from thence.

IT appearing from the last chapter how great a *being* the CREATOR is, it is time to consider what relation he stands in to us, and what is due from us to him. His relation to us, is that of CREATOR; and as such, of *Conservator*, *Sovereign LORD*, and *Ruler*, one that hath an absolute power over us, and all things belonging to us, that can sub-

ject us to what laws he sees fit, and that can reward or punish us as we deserve. And in this case, the least we can do, is to *revere* and fear him at all times, to *worship* and *serve* him with all our power, to *comply* with his holy will sincerely and heartily, and to *obey* him in all things he hath either forbidden, or enjoined. And considering also how great *indulgence* and *love* the CREATOR hath shewn in his works throughout the universe, it naturally follows that we ought to be truly *thankful* to him for his mercy and kindness, and to love him for his love and goodness.

These kind of Conclusions are so natural, that the very heathens have in some measure made them. Thus Cicero's *stoick* before cited, (a) “ Quid vero? hominum ratio non, &c. What? doth not man's reason penetrate as far as even the very heavens? For we alone of all animals have known the risings, settings, and courses of the stars: By mankind it is that the day, the month and year, is determined; that the eclipses of the Sun and Moon are known, and foretold to all futurity; of which luminary they are, how great they

(a) *De Nat. Deor*, L. 2. c. 61.

will be, and when they are to happen. Which thing the mind contemplating, it receives from hence (b) the knowledge of the Gods: from whence arises piety; to which is joined justice, and the other virtues; from which springs that blessed life, which is equal unto, and like that of the Gods themselves, and in no respect yielding to those celestials, except in immortality, which is not necessary to happy living. *And in his book De Legibus, (c) Cicero brings in his collocutor saying, Sit igitur hoc a principio persuasum, &c. i. e.* Let this be what every member of the commonwealth is fully convinced of from the beginning, that the Gods are Lords and Governors of all things; that whatsoever things are done, they are managed by their influence, rule, and divinity; that they merit a great deal of mankind; and observe what every one is, what he doth, what he admits into his mind; with what mind, what piety he cultivates religion; and that they take an account both of the righteous and wicked. For, *saith he*, Minds that are endued with these principles, will scarce ever

(b) *Some read it instead of* Accipit ad cognitionem Deorum; *Accipit ab his* Cognitionem Deorum.

(c) *Lib. 2. c. 7.*

depart from that opinion that is useful and true." And a little after, (d) one of the laws arising from hence he saith is, "Let men approach the Gods with purity, let them practise piety; for he that doth otherwise, God himself will be the avenger of." This purity and sincerity is so necessary a concomitant of religion and divine worship, according to Cicero, that he makes it, in another place, to be that which distinguishes religion from superstition, (e) "*Cultus autem deorum est optimus, &c.*" But that religion, that worship of the Gods is the best, the purest, the holiest, and fullest of piety, that we always revere and worship them with a pure, upright, and undefiled mind and voice. For, *saith he*, not only the philosophers, but our forefathers, have distinguished superstition from religion; "which he assigns the difference of, and then tells us, "that the one hath the name of a vice, the other of praise."

Thus as the heathens have, by the light of nature, deduced the existence and attributes of God from his works, and particularly those of the Heavens; so have they, at the same

(d) *Cap. 8.*

(e) *De Nat. Deor. L. c. 28.*

time, collected what the principal duties are which men owe to God; so reasonable, so natural, so manifest they are to all mankind.

C H A P. IV.

Lactantius his Argument against the Heathen Gods.

THE next inference shall be one made by the eloquent Lactantius: (a) “*Argumentum illud quo colligunt universa Coelestia Deos esse, &c. i. e.* That argument whereby they conclude heavenly bodies to be Gods, proveth the contrary: for if therefore they think them to be Gods, because they have such certain and *well contrived* rational courses, they err. For from hence it appears that they are not Gods, because they are not able to wander out of those paths that are prescribed them: Whereas if they were Gods, they would go here and there, and every where, without any compulsion, like as animals upon the earth do; whose wills being free, they wander hither and thither, as they list, and go whithersoever their minds carry them.

(a) *Institut. L. 2. c. 5.*

Thus Lactantius, with great reason, refutes the Divinity of the *Heavenly bodies*; which, on the contrary, are so far from being Gods, and objects of divine honour and worship, that some of them have been taken to be places of torment. Thus *comets* particularly, which must needs have a very unequal and uncomfortable temper of heat and cold, by reason of their prodigiously near approaches to the Sun, and as great recesses from it. Thus according to the before commended Sir Isaac Newton's (b) computation, the comet 1680, in its perihelion, was above 166 times nearer the Sun than the earth is; and consequently its heat was then 28000 times greater than that of summer: So that a ball of iron as big as the earth heated by it, would hardly become cool in 50000 years. Such a place therefore if designed for habitation, may be imagined to be destined rather for a place of torment, than any other sort of living.

But above all, the Sun itself, the great object of heathen worship, is, by some of our own learned countrymen, supposed to be probably the place of *Hell*. Of which Mr.

(b) *Principia*, p. 466.

Swinden hath written a treatise called, “ An enquiry into the nature and place of Hell.”

C H A P. V.

This Survey of the Heavens teaches us not to overvalue the World; with Reflections of the Heathen Writers thereupon.

FROM the consideration of the prodigious magnitude and multitude of the heavenly bodies, and the far more noble furniture and retinue which some of them have more than we, we may learn not to overvalue this world, not to set our hearts too much upon it, or upon any of its riches, honours, or pleasures. For what is all our globe but a point, a trifle to the universe! a ball not so much as visible among the greatest part of the Heavens, namely the fix'd stars. And if magnitude or retinue may dignify a Planet, *Saturn* and *Jupiter* may claim the preference: Or if proximity to the most magnificent globe of all the system, to the fountain of light and heat, to the centre, can honour and aggrandize a Planet, then *Mercury* and *Venus* can claim that dignity. If therefore our world, be one of

the inferior parts of our system, why should we inordinately seek and desire it? But above all, why should we unjustly grasp at it, and be guilty of theft or rapine, lying or cheating, or any injustice, or sin for it? Why should we sacrifice our innocence for it, or part even only with a good name for it, which Solomon saith (a) *is rather to be chosen than great riches*? Why should we do thus, if we were sure of gaining the whole terraqueous globe, much less do it for a small pittance of it, as the best empire in the world is? For as our blessed Saviour argues, Matt. xvi. 26. "What is a man profited, if he should gain the whole world and lose his own soul? or what shall a man give in exchange for his soul?"

But passing over the arguments which Christianity suggests, let us see how some of the heathen writers descant upon this subject. Pliny (b) is very pathetic in his reflections, when he had shewn what little portions of the earth were left for us, and what large tracts were rendered (as he thought) useless, the frigid zones being frozen up with excessive cold, the torrid zone being burnt up (as the

(a) *Prov.* 22. 1.

(b) *Nat. Hist. L.* 2. c. 68.

opinion then was) with an excessive heat, and other parts drowned by the sea lakes and rivers, and others covered with large woods, desarts, or barren mountains: he then exclaims thus, *Hae tot portiones terrae, &c. i. e.* These little parcels of land *which are left for our habitation*; yea, as many have taught, this point of the world (for no other is the earth in respect of the universe) this is the matter, this the seat of our glory: Here it is we bear our honours; here we exercise our authority; here we covet riches; here mankind makes a bustle; here we begin our civil wars, and soften the earth with mutual slaughters.” And then having shewn how by fraud and violence men strive to enlarge their estates, saith he, “What a little part of those lands doth he enjoy? And when he hath augmented them, even to the measure of his avarice, what a poor pittance is it that his dead body at last possesseth?” Thus Pliny. And after the same manner Seneca reflects upon the matter (c) when he shews how virtue tends to make a man compleatly happy; among other things, by preparing him for the society of God, by e.

O

(c) *Nat. Quaest. L. Praef.*

nabling the mind, to soar above the things here below, and to make him laugh at the costly pavements of the rich, yea, the whole earth with all its wealth. “Nec enim potest, *saith he*, ante contemnere porticus, &c. *i. e.* “A man can never be able to slight the stately piazzas, the noble roofs shining with ivory, the curiously clipped woods, and the pleasant rivulets conveyed to the houses, untill he hath surveyed the whole world, and spying from above our little globe of earth, covered in a great measure by the sea; and where it is not, is far and near squalid, and either parched with heat, or frozen with cold, he saith to himself, Is this that point, which by fire and sword is divided among so many nations? O how ridiculous are the bounds of mortals! The Ister bounds the Dacians, the Strymon the Thracians, Euphrates the Parthians, the Danube parteth the Sarmathians and Romans, the Rhine gives bounds to Germany, the Pyrenees to France and Spain, and between Ægypt and Æthiopia lie the vast uncultivated sandy desarts. If any could give human understanding to ants, would not they too divide their molehills into divers provinces? And when thou liftest up thyself in thy truly great providence, and shall see the armed hosts

passing here, and lying there, as if some great matter was to be acted, consider that this is no more than the running of ants in a molehill. For what difference between them and us, but only the measure of a little body? That is but a point in which thou failest, in which thou wagest war, in which thou disposest of kingdoms. But above there are vast spaces, to whose possession the mind is admitted, provided it brings but little of the body along with it, that it is purged of every vile thing, and that it is nimble and free, and content with small matters." And so he goes on to shew, that when the mind is once arrived to those celestial regions, how it comes to its proper habitation; is delivered from its bonds; hath this argument of its Divinity, that divine things delight and please it, and is conversant with them as its own; that it can securely behold the rising and settings and various courses of the stars; that it curiously pries into all those matters, as nearly appertaining to itself; that then it contemns the narrow bounds of its former habitation, it being but a trifling space, of a few days journey, from the utmost limits of Spain to the very Indies; whereas the celestial regions afford a path for the wander-

ing of the swiftest star for 30 years, without any resistance; in which regions he tells us the mind arrives to the knowledge of those things at last, which it had before long enquired after, and there begins to know GOD. Thus Seneca; which shall suffice for this third inference.

C H A P. VI.

That we should aspire after the heavenly State.

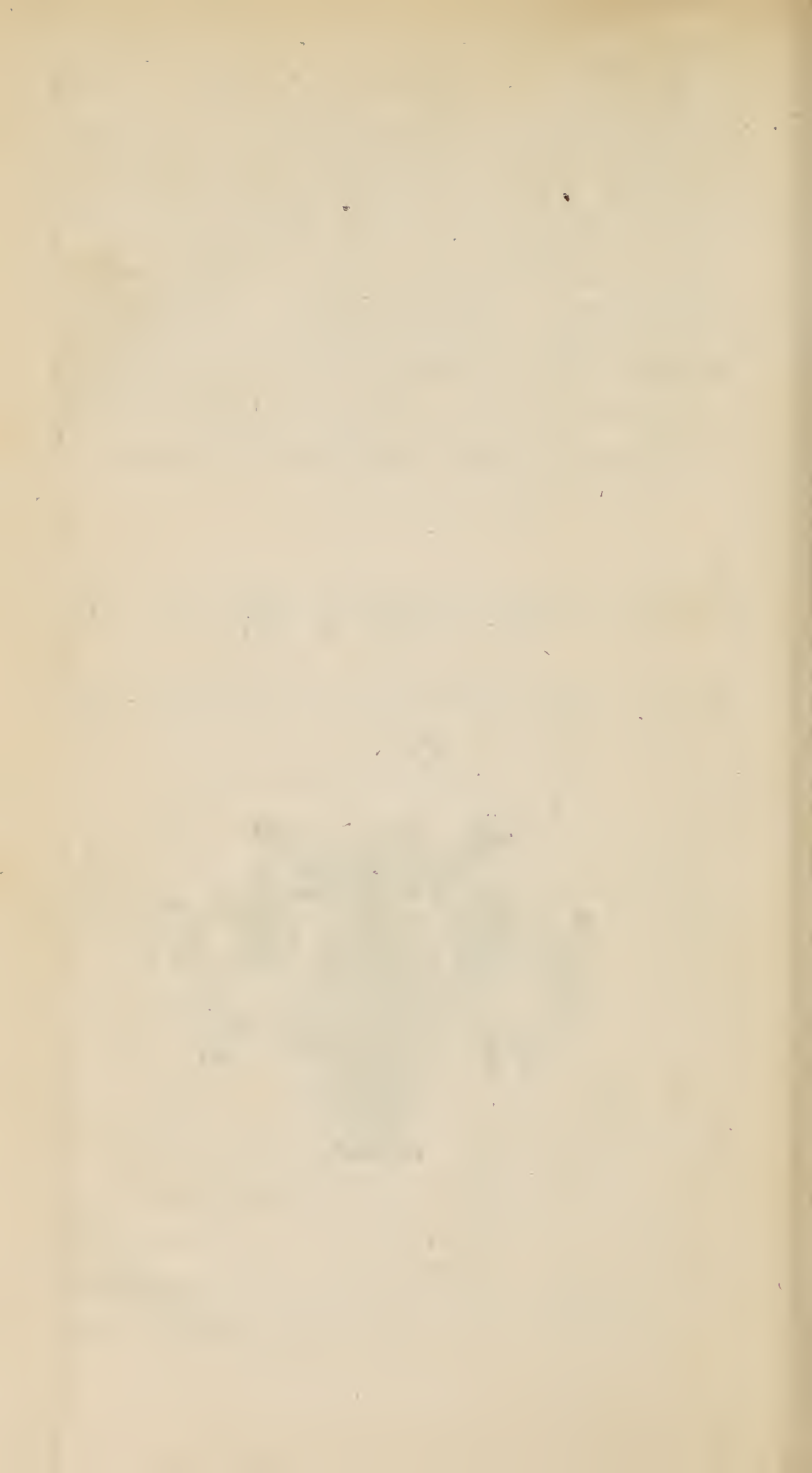
I Shall only deduce one thing more from my preceeding view of the Heavens, and that is, to aspire after the heavenly state, *to seek the things that are above.* We are naturally pleased with new things; we take great pains, undergo dangerous voyages, to view other countries: with great delight we hear of new discoveries in the Heavens, and view those glorious bodies with great pleasure through our glasses. With what pleasure then shall departed happy souls survey the most distant regions of the universe, and view all those glorious globes thereof, and their noble appendages with a nearer view? Only let us take especial care to “set our affections on

things above;" to be "spiritually not carnally-minded;" and so to "run the race which Christ hath set before us," that we may arrive to that place which he hath prepared for his faithful servants, that he may "receive us unto himself, that where he is, there we may be also; in whose presence is fulness of joy, and at whose right hand are pleasures for evermore."

F I N I S.

O 3





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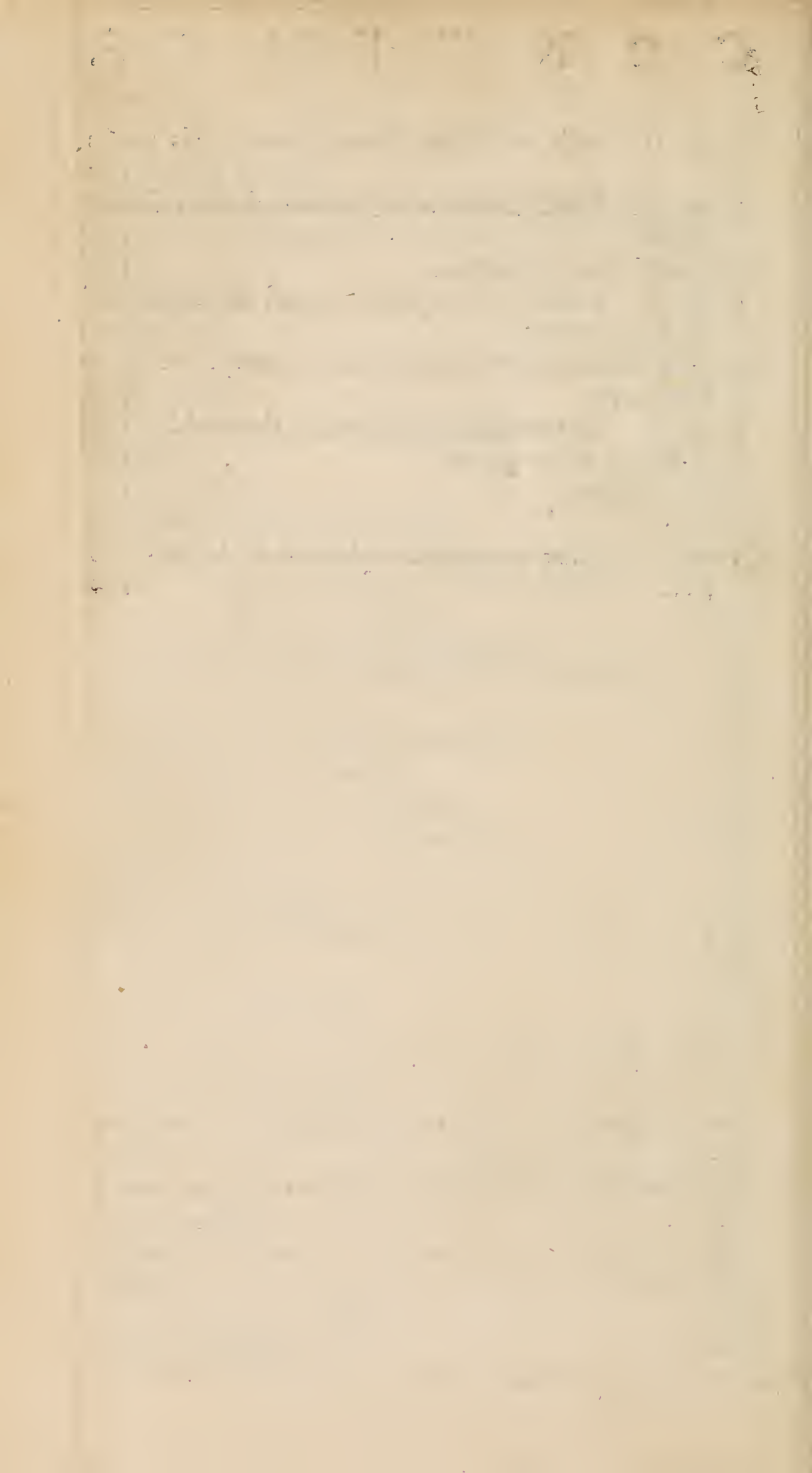
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Fig: 12.

Fig: 6.



Fig: 9.

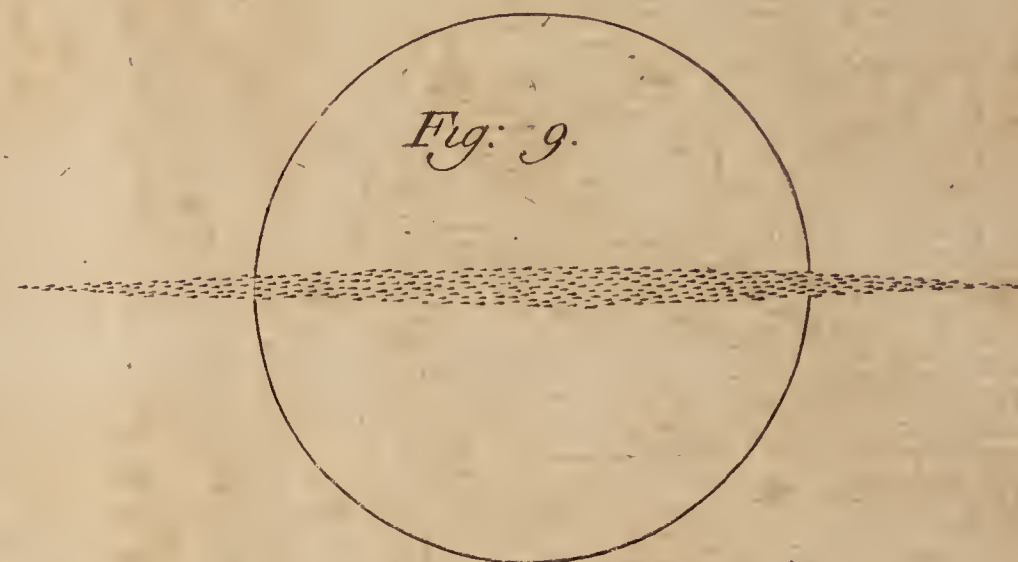


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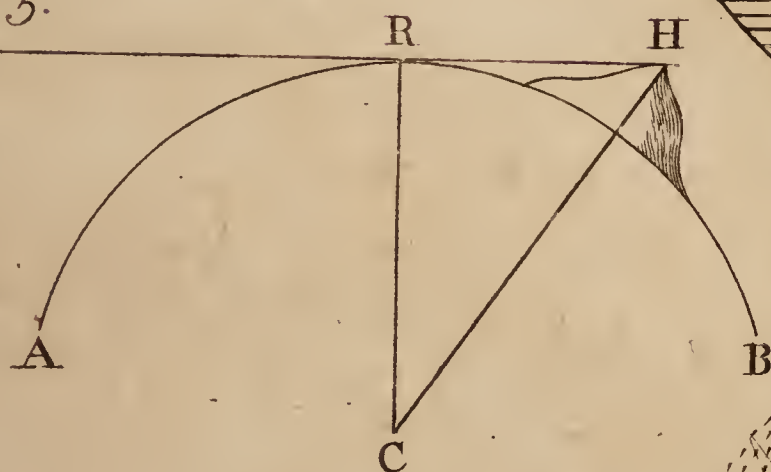


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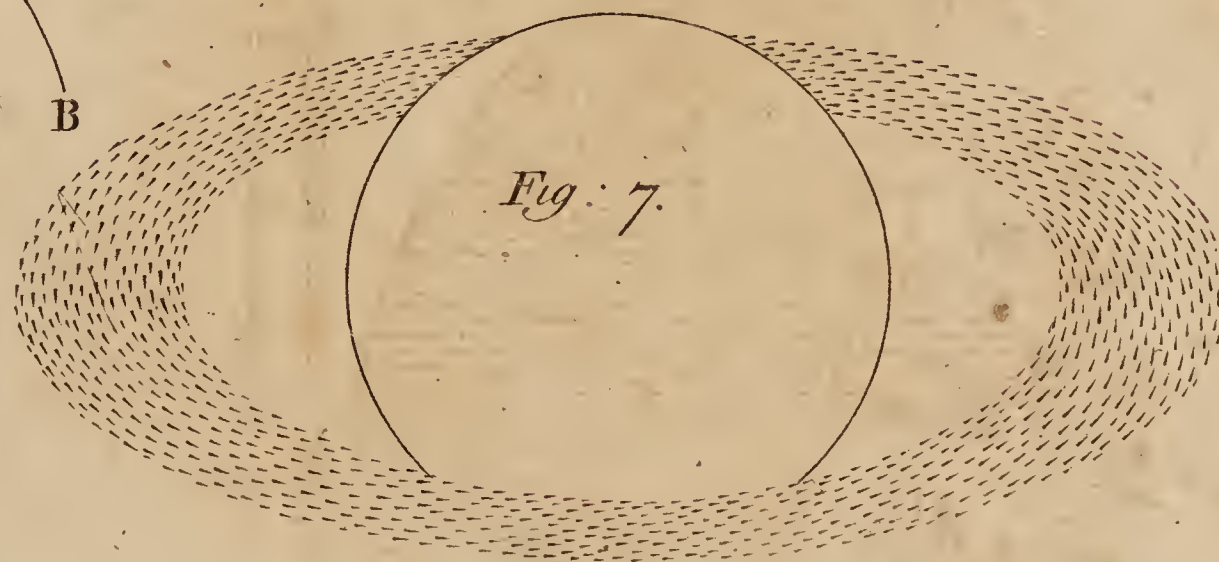


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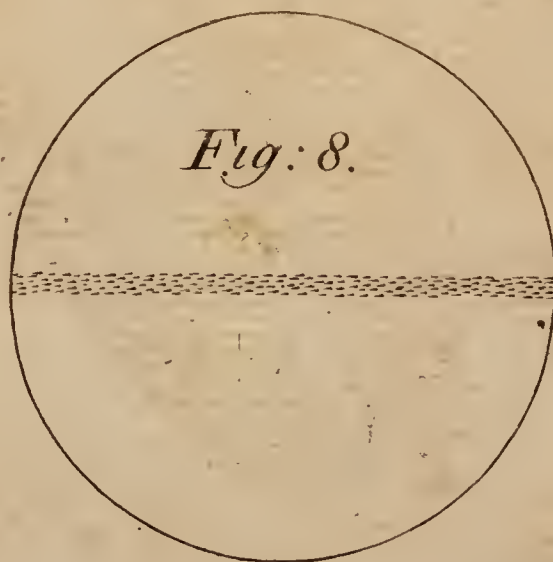


Fig: 11.



Fig: 4.

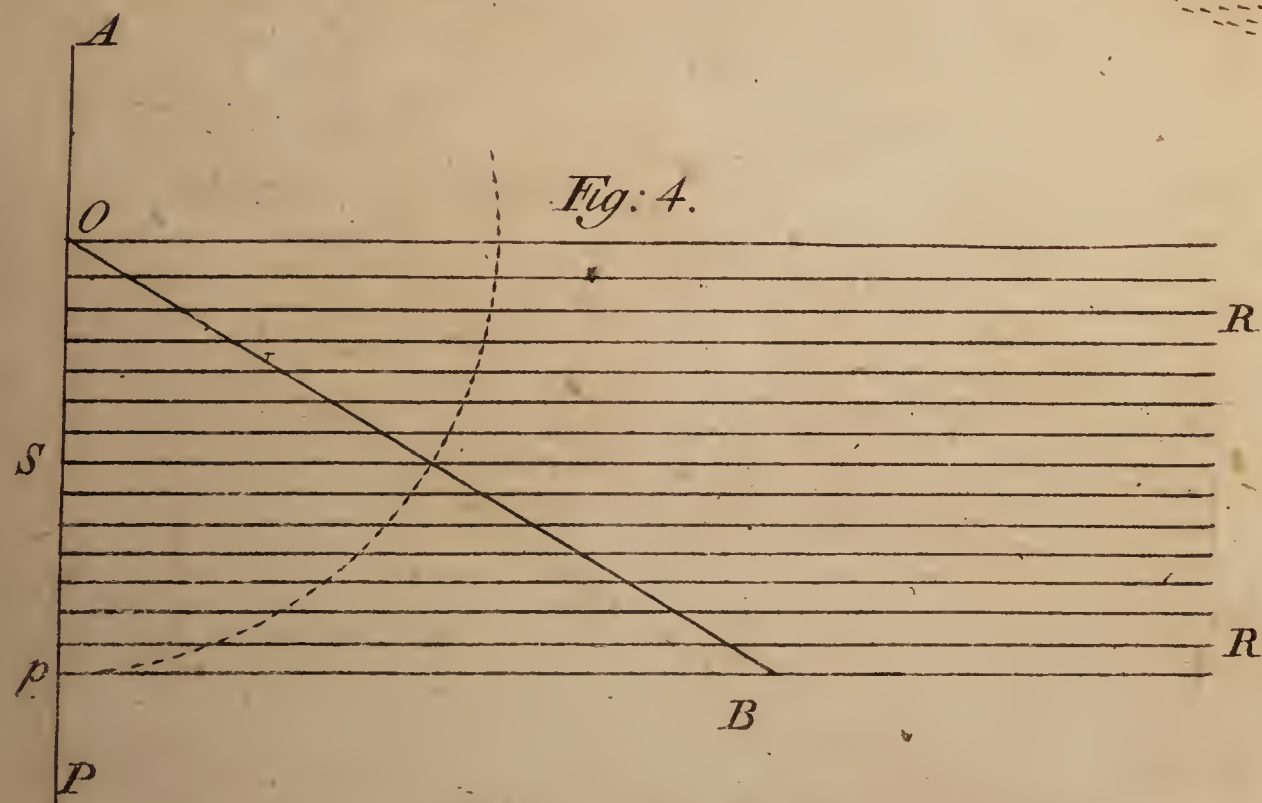


Fig. 10

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Fig. 1.



Fig. 2.



Fig. 3.



AN ALPHABETICAL

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